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quantities; but it ought never to be applied but by experienced persons.

Charles. This will not dissolve in water?

Tutor. Not in cold water; nor, indeed, in boiling water, with so little as 1000 times its weight of that fluid.

PKP

Dialogues in Chemistry,

INTENDED FOR

THE INSTRUCTION AND ENTERTAINMENT

OF

YOUNG PEOPLE:

IN WHICH

THE FIRST PRINCIPLES OF THAT SCIENCE ARE
FULLY EXPLAINED.

TO WHICH ARE ADDED,

QUESTIONS AND OTHER EXERCISES

FOR THE

EXAMINATION OF PUPILS.

BY THE REV. J. JOYCE,
Author of Scientific Dialogues, Dialogues on the Microscope, &c.

FROM THE THIRD LONDON EDITION,
CORRECTED AND VERY MUCH ENLARGED; WITH AN ACCOUNT
OF ALL THE LATE DISCOVERIES, AND ADDITIONAL NOTES BY
AN AMERICAN PROFESSOR OF CHEMISTRY.

IN TWO VOLUMES.

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WITHDRAWN

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CONVERSATION I.

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Of Acid Supporters.—Of the Nitric and Nitrous Acids.

TUTOR—CHARLES—JAMES.

TUTOR. The next division of the acids is, according to the plan which I have adopted from Dr. Thomson, the *acid supporters.*

Charles. What are the characteristics of these acids ?

Tutor. 1. They cannot be produced by combustion, and are incombustible ; 2. They are capable of supporting combustion ; and 3. They are decomposed by exposure to a high temperature ; in that case, the oxygen escapes in a state of gas. Among these are all the metallic acids.

James. How many of the acids do you arrange under this class ?

Tutor. There are seven, *viz.* the NITRIC, MURIATIC, ARSENIC, TUNGSTIC, MOLYBDIC, CHROMIC, and COLUMBIC acids. Of these, the first two, being of great importance in Chemistry, I will describe to-day; the others will come in under their respective bases; thus arsenic acid will be described with arsenic, and so of the rest.

Charles. Is the nitric acid formed from nitre?

Tutor. It is one of the component parts of nitre, which is itself a compound of oxygen and nitrogen or azote, in the proportion of about seven parts of oxygen and three of nitrogen.

James. Can it be formed from these gases?

Tutor. If the gases be mixed in a glass tube, and a number of electric explosions be passed through them, the gases will combine, and nitric acid will be formed about the inside of the tube. It is one of the most corrosive acids.

Charles. This is strange, considering that the air which we breathe is formed of the same gases.

Tutor. The proportions are somewhat different, and the gases, that make up the atmospheric air, are only mixed; but in forming the nitric acid there is probably a complete chemical union.

James. Can you produce the gases from pure nitric acid again?

Tutor. The acid may be easily analysed, by forcing it through a red hot porcelain tube, and the gas obtained will be found to be a mixture of the azotic and oxygen gases.

Charles. What are the properties of this acid?

Tutor. When newly prepared and very pure, it is a transparent and colourless liquid: but the action of the light will drive off a part of the oxygen, and then it becomes yellow. It is very corrosive, and tinges the skin wherever it touches. Nor will the tinge disappear but with the skin itself. It emits very penetrating and disagreeable fumes.

James. Does it combine readily with water?

Tutor. It has a strong affinity for water, and has never been obtained, in the liquid state, free from it. It is, when pure, much heavier than water; and, when suddenly mixed with it, a considerable heat is produced.(*a*)

Charles. Is nitric acid ever obtained in the form of gas?

Tutor. It may be regarded, when perfectly pure, as a gaseous body; and the liquid acid consists of this gas condensed by water, in the proportion of about three parts of acid and one of water. Diluted nitric acid has been long known under the name of *aqua-fortis.*

James. That is used, I believe, in many manufactures?

Tutor. It is employed in dying, in refining gold, and in medicine.

Charles. How is it obtained on the large scale?

Tutor. In large manufactories it is prepared by distilling three parts of nitric and one of sulphuric acid in a glass retort A (Plate I, Fig. 7.) The retort is luted into a tube *x*, which is connected with the receiver R; from this passes a glass tube to a bottle *z*, with two mouths.

James. What is the other mouth of the bottle for?

Tutor. A tube passes from it to the pneumatic apparatus. The nitric acid comes over, and is condensed in the receiver, while the common air of the vessels, and a quantity of oxygen gas, which is evolved in the business, passes to the pneumatic apparatus, and the water in the bottle *z* is impregnated with some of the acid that is not condensed in the receiver.

Charles. By the definition, this acid is incombustible.

Tutor. True: but it is readily decomposed when made hot; and, if poured upon sulphur, or phosphorus, it sets them on fire. It inflames charcoal also, provided it be dry and minutely divided, and likewise the essential oils with considerable violence. In this glass is some oil of turpentine, on which I will pour a little nitric acid, but, to save my eyes from injury, I shall tie the phial, which contains the acid, to the end of a stick five or six feet long, by which means I can mix the two liquids without being near them.

James. How is this violent inflammation accounted for?

Tutor. It is occasioned by a decomposition both of the acid and the oil; the oxygen of the acid unites with the two principles of which the oil is composed, *viz.* the carbon and hydrogen, while it gives out a large quantity of caloric.

This acid is capable of reducing almost all the metals to the state of oxydes; it will even inflame zinc, bismuth, and tin, if poured on them in a state of fusion ; and iron filings also, if they are perfectly dry. I will pour some strong nitric acid on these iron filings.

Charles. What causes the great heat and red fumes that are produced ?

Tutor. The acid is partly decomposed ; the oxygen combines with the metal, giving out caloric at the same time, and the red fumes are nitric gas ; the redness depends on its combining with the oxygen of the atmosphere, for, if the gas were received in a glass under water, it would be perfectly colourless.

Charles. Is the redness a proof that an acid is formed ?

Tutor. It is, as may be shown by the following experiment. I have pasted a slip of litmus paper on the side of this glass jar ; and into the jar, filled with water, I will send nitrous gas to displace the water below the level of the paper. The colour of the litmus will remain unchanged ; but, as soon as I throw up a portion of oxygen gas, or even of atmospheric air, it will change to red, which is a proof that an acid has been formed.

James. Does the nitric acid combine with water ?

Tutor. Yes, in any proportion ; and, during the combination, caloric is given out. If, however, snow be used instead of water, a contrary effect will be produced, for in this case caloric will be absorbed. If four parts of light snow be mixed with one of nitric acid, a degree of cold much below the freezing point will be produced.

Charles. How do you account for this?

Tutor. It is owing to the great affinity that the acid has for water, which forces the snow to draw from neighbouring bodies the caloric that it stands in need of before it can become liquid.

James. Does this acid combine with the alkalies, earths, and metallic oxydes?

Tutor. It does, and the compounds are called *nitrates;* thus we have the nitrate of potass, barytes, silver, &c.

Charles. Does nitr*ous* acid differ from nitric acid, only as it contains a smaller quantity of oxygen?

Tutor. No: nitr*ous* acid is a compound of nitr*ic* acid and nitrous gas.* The properties of this acid are similar to those which we have described as belonging to the nitric acid. It combines with the alkalies and earths, forming salts called nitr*ites;* but of these little is at present known.

James. Is there nothing peculiar belonging to the nitrous acid?

Tutor. The colour of it depends on its strength. Water, impregnated with this acid, in a state of vapour, becomes first blue, then green, and lastly yellow. This acid, or nitric acid combined with nitrous gas, is chiefly used in the manufactures, and by chemists in their experiments.

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* See vol. i. Conversation xv.

CONVERSATION II.

Of the Muriatic Acid.

TUTOR. The muriatic acid exists in great abundance in the natural state, united to different bases, particularly to soda, lime, and magnesia.

Charles. How is it obtained?

Tutor. Although the base of this acid is not known, the acid itself is easily obtained from sea salt, which, from the circumstance of its containing a large portion of muriatic acid, is denominated muriate of soda.

James. Is the muriatic acid in the form of gas, or a liquid?

Tutor. The purest acid exists in the state of gas, which, combined with water, is the liquid muriatic acid, and in this state it is usually employed. The gas is obtained by putting two parts of muriate of soda, (common salt,) thoroughly dried, into a bottle *c* (Plate I, Fig. 8.) and introducing, by means of the vessel *a*, some concentrated sulphuric acid into the bottle.

Charles. Is *b* a stop-cock ?

Tutor. Yes : and this is a neat contrivance to prevent the gas, which is of a very suffocating nature, from spreading over the room. In the part *a* the acid is enclosed ; and, when it is luted into *c*, and the bent tube is introduced through the mercurial trough under a receiver, the stop-cock *b* is turned, and the muriatic acid gas comes over in great quantities.

James. What are the properties of this acid in a state of gas ?

Tutor. Besides its pungency, already noticed, when brought into contact with common air, it occasions a white cloud ; it extinguishes a lighted candle, but before the flame goes out, it assumes a *greenish hue ;* and a white vapour surrounds the extinguished wick ; it melts ice like a red-hot coal ; it is rapidly absorbed by water, and, in this state, when exposed to the air, it gives out white fumes.

James. What is the cause of these fumes ?

Tutor. It is a combination of the gas with the moisture of the atmosphere.

Charles. Is its affinity for water the cause of its melting ice and snow ?

Tutor. It is. This acid unites readily with the alkalies, and with most of the earths and metallic oxydes, forming with them salts called *muriates ;* thus we have, besides the muriate of soda, the muriates of potass, ammonia, barytes, lime, &c.

A small quantity of this acid, poured into a so-*tion of nitrate* of silver, which is a solution of silver in nitric acid, will occasion a copious precipitation.

Charles. What is the precipitate?

Tutor. The muriatic acid seizes on the silver, and forms a muriate of silver, which is the precipitate. It readily dissolves iron and zinc, and, with the assistance of heat, it dissolves the other metallic substances. This acid may be made to combine with oxygen; and, according to the quantity absorbed, it is either called oxymuriatic or hyperoxymuriatic acid.

James. Why is this name given to it, instead of using the term muriat*ous* for the lower and muriat*ic* for the higher degree of oxygenation?

Tutor. Because it differs, in its properties, very materially from the other acids. Instead of becoming, like them, more dense and more acid by an addition of oxygen, it is rendered on the contrary more volatile, more pungent, but less acid, and less absorbable by water. This is the cause of the difference in the nomenclature. But, as we shall soon see, these names have given way to another, viz. *chlorine.*

James. What are the properties of the acid in this state?

Tutor. In a state of gas it is very suffocating, and cannot be breathed without danger, and evident injury to the health; it will, however, support combustion; it discharges vegetable colours, and is, on that account, much used in bleaching.

Charles. Does it unite with the alkalies and earths?

Tutor. In the state of hyperoxygenation, it combines with different bases, forming with them salts called hyperoxygenized muriates. Phosphorus plunged into it immediately inflames; so also does melted sulphur, and charcoal, when reduced to fine powder and made pretty hot.(*a*) It oxydizes all metals, and these, when reduced to thin leaves, it will inflame.

James. Will gold leaf burn by being introduced into this gas?

Tutor. It will, and so will fine copper foil; and, as the metal combines with the oxygen, the acid dissolves it, and acquires a green colour. Arsenic burns in oxymuriatic gas, with a blue and green flame; bismuth, with a lively bluish flame; nickel with a white flame, bordering on yellow; cobalt, with a white flame, approaching to blue; zinc with a lively white flame; tin, with a feeble bluish flame; lead, with a sparkling white flame; copper and iron, with a red flame. Several of the metallic sulphurets, as the sulphuret of mercury, or cinnabar, and the sulphuret of antimony, take fire when thrown in the state of powder into this gas.

Charles. For what is the oxymuriatic acid used?

Tutor. It is used in bleaching cloth, wax, old engravings, and paper. When two parts of nitric acid and one of muriatic acid are mixed together, the compound has precisely the qualities of the oxymuriatic acid; this mixture was formerly called *aqua-regia* from its property of dissolving gold, which no other acid will; but it is now denominated nitro-muriatic acid.

James. How is this acid obtained?

Tutor. It was at first procured by distilling the muriatic acid from the oxyde of manganese, in Woulfe's apparatus. But it is now obtained, at an easier rate, from common salt.

Charles. What do you mean by Woulfe's apparatus?

Tutor. In many instances, a substance raised by distillation is partly a condensable liquid and partly a gas, which is not condensed till it is brought into contact with water. To effect this double purpose, a series of receivers, termed Woulfe's apparatus, from the inventor, is employed.—See Plate II, Fig. 9. The first receiver, *b*, has a right angled glass tube, open at both ends, fixed into its tubulure; and the other end of the tube is made to terminate beneath the surface of the distilled water contained in the three-necked bottle *c*. From another neck of this bottle a second pipe proceeds, which ends under the water in the second bottle *d*. To the central neck, a straight tube, open at both ends, is fixed, so that the lower end may be a little beneath the surface of the liquid; this is a safety pipe.

James. Are the materials to be distilled introduced into the retort *a*?

Tutor. Yes: and, when heat is applied, the condensable vapour collects in a liquid form in the balloon *b*, while the gas passes through the bent tube into the water in *c*, which continues to absorb it till saturated.

Charles. What will become of the rest when the water of the first bottle can absorb no more?

Tutor. The gas, in that case, passes uncondensed through the second right angled tube into the water of the second bottle, which, in its turn, becomes saturated; after this, the gas may be conducted to other bottles, in any number, or may be suffered to go off through the tube.

CONVERSATION III.

Of Chlorine, Euchlorine, and the Compound.

CHARLES. You said, yesterday, that the name of oxymuriatic acid had given way to another term, did you mean that the denomination *chlorine* was substituted for it ?

Tutor. I did : for, according to Sir Humphrey Davy's hypothesis, founded on experiments, which are admitted as accurate by all chemists, oxymuriatic acid is considered as a simple body, which contains no oxygen.

James. If this be the case, then, indeed, the old name oxymuriatic acid must be improper ; *chlorine* then, I suppose, is a word to denote a newly discovered elementary substance.

Tutor. Just so. It is taken from the Greek χλωρος, signifying green, on account of its yellowish *green* colour.

Charles. What proof is there that chlorine is an elementary body ?

Tutor. It was discovered, so long ago as the year 1774, by Scheele, who immediately regarded it as an undecompounded body; but he rather assumed the fact than attempted to give a regular proof of it.

James. Did not its former name, *oxymuriatic* acid, lead to the conclusion that it was muriatic acid combined with oxygen?

Tutor. Certainly: and such was the theory of the great French chemists, especially Lavoisier and Berthollet. But this idea is generally abandoned: there are, however, chemists still in that country, in this, and in others, who maintain, that it is a compound of oxygen and an unknown body, which they call dry muriatic acid.

Charles. Is not the theory even yet settled?

Tutor. No: Sir Humphrey Davy, in his *Elements of Chemical Philosophy*, says, "the weight of chlorine, its absorbability by water, its colour, and the analogy of some of its combinations to bodies known to contain oxygen, are arguments in favour of its being a compound; and it is possible, that oxygen may be one of its elements, or that oxygen and chlorine are similarly constituted. I have made a number of experiments with the hopes of detecting oxygen in it, but without success: none of its compounds with inflammable bodies, or metals, will afford this principle; charcoal, intensely ignited in it, undergoes no change, nor is it altered by the strongest powers of electricity. Should oxygen ever be procured from it, some other form of matter, possibly a new one, will at the same time be discovered, as entering into its constitution; and, till it is decompounded; it must be regarded, according to the just logic of Chemistry, as an elementary substance."

James. Are there any simple and clear experiments that go to settle the matter?

Tutor. The most decisive fact in support of the new doctrine, that is, of chlorine being an elementary substance, is, that, if hydrogen gas and oxymuriatic acid gas, or chlorine, be mixed together, both gases disappear, and muriatic acid gas is formed.

Charles. Then, if I understand the theory, as hydrogen and oxygen go to the formation of water, so hydrogen and chlorine go to the formation of muriatic acid.

Tutor. Just so: hence, if oxygen be esteemed elementary, so also may chlorine.

James. The argument seems quite decisive.

Tutor. There are some things that appear to go against the doctrine; thus, muriatic acid gas, in its dryest state, always contains a certain quantity of water; this being the case, the water is applied by the union of the hydrogen gas with the oxygen of the chlorine, and the compound resolves itself into the base of the muriatic acid and water; that is, muriatic acid gas.

Charles. Did you not say yesterday, the oxymuriatic acid gas was obtained from a mixture of muriatic acid and the oxyde of manganese?

Tutor. I did; but, by the new theory, this fact is easily accounted for. The muriatic acid is decomposed ; its hydrogen unites with the oxygen of the manganese to form water, and the chlorine appears in its separate state.

James. Has this substance, chlorine, ever been found in a state of purity, in nature ?

Tutor. No ; but it exists in many compounds, particularly in common culinary salt.

Charles. Supposing chlorine a simple substance, how do you account for its discharging colours from vegetable substances, as you mentioned yesterday ?

Tutor. M. Berthollet assumed, that chlorine destroyed colours by parting with its oxygen ; but, by the new theory, the oxygen is derived from the water by a double affinity ; that of hydrogen for chlorine, and of the colouring matters for oxygen.

James. I think I have heard of old prints being cleaned by the oxymuriatic acid gas.

Tutor. This is accounted for in the same manner. The unprinted parts will be cleaned by it, but upon the printed parts it will have no effect, because the printers' ink, consisting of oil and lampblack, is not acted upon by the acids.

Charles. Can chlorine be obtained from other substances than those which you have mentioned ?

Tutor. Yes : mix eight ounces of muriate of soda, that is, common salt, with three ounces of powdered manganese, and put them into a tubulated retort, and pour on the materials dilute *sulphuric acid ;* and, when they have become cool, *after dilution,* a gentle heat is to be applied, and gas will be produced. Do you recollect the properties of this gas?

James. Yes, I think I do: it has a yellowish green colour, which suggested the name chlorine: it has a pungent and suffocating smell: it is heavier than common air: it destroys all vegetable colours; and it is readily absorbable by water.

Tutor. When a receiver, filled with this gas, is surrounded with snow, or pounded ice, the gas forms on its inner surface a solid concretion, of a yellowish colour, resembling, in its ramifications, the ice which is deposited on the surface of windows during a frosty night. By a moderate increase of heat this crust melts into a yellowish oily liquid, which, by a farther elevation of temperature, passes into a state of gas.

Charles. Can chlorine be made readily to combine with other substances?

Tutor. It may; and the compounds, in many cases, possess remarkable properties. The salts, which are called hyperoxymuriates, and oxymuriates, are compounds of metallic bodies with chlorine and oxygen. The oxygen is held in them by a very weak attraction, and therefore readily given off to colouring or inflammable matters.

James. What do you mean by hyperoxymuriates?

Tutor. There are several of them, as the hyperoxymuriate of potass, soda, ammonia, &c. all of which have separate and different properties.

Charles. How are they obtained?

Tutor. As an instance, we may take the hyperoxymuriate of potass, which is formed by passing oxymuriatic acid gas, as it proceeds from the mixture of muriate of soda, or common salt, sulphuric acid, and manganese, through a solution of caustic potass. The solution, when saturated with gas, may be gently evaporated, and the first products of crystals are to be reserved for use.

James. What properties attach to this salt?

Tutor. It has several curious ones. The following experiments, mentioned by Dr. Henry, may be made with it; but they should not be undertaken but by experienced hands.

Experiment 1. Put two grains in powder in a mortar, and add one grain of sulphur. Mix them very accurately, by gentle triture, and then, having collected the mixture to one part of the mortar, press the pestle upon it suddenly and forcibly: a loud detonation will ensue.

Ex. 2. If the mixed ingredients be wrapped in some strong paper, and then struck with a hammer, a still louder report will be produced.

Ex. 3. If five grains of this salt be mixed with half the quantity of powdered charcoal, in a similar manner, and the mixture be strongly triturated, it will inflame, but with little noise.

Ex. 4. Mix a small quantity of sugar with half its weight of the salt; and on the mixture pour a very little strong sulphuric acid; and an instantaneous and vehement inflammation will take place.(a) A mixture of this kind is the basis of more inclined to the yellow. A very gentle heat causes this gas to explode; and, in the action, the elements are separated with great violence, and with some light.

James. Do you call this a decomposition?

Tutor. Certainly: and the facility with which this is done renders it very difficult to ascertain the action of combustible bodies upon it. The metals, which act upon chlorine, will not act upon this at common temperatures; but, when the oxygen is separated, then they inflame in the chlorine, of which the following experiment will be an exemplification:—

Experiment. Let a little gold leaf be introduced into a bottle filled with euchlorine, it will undergo no change: but, if a heated glass tube be applied to the gas in the neck of the bottle, a decomposition takes place, and the oxygen and chlorine will be detached from each other; and, at the same moment, the leaf will inflame and burn with great brilliancy.

Charles. Do chlorine and oxygen combine in any other proportions than those which form euchlorine?

Tutor. They do, and form a compound, containing a larger proportion of oxygen than euchlorine. This compound is obtained by mixing with fifty or sixty grains of the powdered hyperoxymuriate of potass a small quantity of sulphuric acid. When well incorporated, a solid mass will result, of a bright orange colour. This is to be introduced into a small glass retort, which is to be exposed to the heat of water gradually warmed, but not brought to the boiling point. The gas may be received over mercury, on which it has no action at common temperatures.

James. In what does it differ from euchlorine?

Tutor. It has a much more brilliant colour than euchlorine: it is much more rapidly absorbed by water; and has a peculiar aromatic smell, not at all like the smell of chlorine.

Charles. Can chlorine and nitrogen be united?

Tutor. Not immediately; but a compound of these gases may be formed by passing the chlorine through a solution of nitrate of ammonia. The gas is rapidly absorbed, and a film appears on the surface, which soon collects into yellowish drops, that sink to the bottom of the liquor. This yellowish and oily fluid is the most powerfully detonating compound that is known.

James. Does it explode of itself?

Tutor. When gently warmed, it explodes with such violence, that it would be extremely dangerous to use a quantity of it larger than that of a grain of mustard seed. M. Dulong, who discovered this gas, was severely wounded by it. And Sir Humphrey Davy had a very serious injury done to his eyes in repeating the experiment.

Charles. Is heat necessary for the explosion?

Tutor. Not in all cases: if a globule of the fluid be thrown into olive oil, turpentine, or naphtha, it explodes without heat, and so violently as to shatter the glass vessel in which it takes place.

James. Is it known of what proportions this compound consists?

Tutor. These are not exactly known; but, from the experiments of Sir Humphrey Davy, he concludes it consists of about ninety-one of chlorine and nine of nitrogen.

Charles. Have chlorine and hydrogen any action upon one another?

Tutor. Yes, they have. A mixture of the two gases, in equal volumes, is slowly absorbed under common circumstances; but, if the direct rays of the sun be thrown upon the mixture, the two gases diminish with considerable rapidity; and, if the quantity of the two gases be large, they even explode, which, says Dr. Henry, "is a striking instance of the agency of light in promoting chemical combination."

James. Will bodies burn in chlorine gas as they do in oxygen gas?

Tutor. Potassium, heated in chlorine gas, burns more vividly than in oxygen; and in the combustion there is an absorption of more than an inch of gas to the grain of metal.

Charles. What is the result of this combustion?

Tutor. It is a neutral compound resembling what results from heating potassium in the muiatic acid gas. Sodium burns in chlorine with imilar appearances.

When either of these new metals, (potassium r sodium,) having been previously made to ab-orb a certain quantity of oxygen, is heated in hlorine gas, the latter disappears, and oxygen gas, precisely equivalent to what had been con-lensed, is liberated.

James. But is it certain that the oxygen does ot proceed from the chlorine ?

Tutor. As the oxygen is always evolved in uantities proportional precisely to what was aken up, however variable the quantity of the hlorine, Sir Humphrey Davy considers this as roving, that oxygen does not proceed from the hlorine, but the oxyde ; and that chlorine is a imple body, which attracts the metals in ques-ion more strongly than oxygen attracts them.

Charles. Does it act a similar part with re-gard to other oxydes.

Tutor. Yes, oxygen may be expelled in the ame way from barytes, strontites, and lime ; which, you know, are now all found to be oxydes.

A mixture of equal volumes of chlorine and arbonic oxyde gases, dried by means of fused muriate of lime, and exposed to the direct and strong rays of the sun, affords a compound call-ed *phosgene* gas, which is one of the heaviest gases known, and has an intolerably pungent odour. This gas is decomposed by the metals, *which unite with* the chlorine, while a volume of the carbonic oxyde is liberated, equal to the bulk of the original gas. It condenses four times its volume of ammoniacal gas, and the product is a white neutral salt.

James. Does chlorine combine with sulphur.

Tutor. It does ; and the result is an oxymuriate of sulphur, in a fluid state, which is volatile at a heat below that of boiling water. It emits fumes, which are extremely acrid, and which excite a copious flow of tears. This substance decomposes water ; of which the hydrogen forms, with chlorine, muriatic acid, while the sulphur, with the oxygen of the water, composes sulphuric acid.

Charles. Has chlorine any action upon the old metals, as well as upon the newly discovered ones ?

Tutor. Almost all the metals, in a state of minute division, such as gold and silver leaf, take fire spontaneously and burn in this. Iron, zinc, copper, &c., must, to be enflamed, be reduced to the state of extremely fine filings. The combustion of the metals in the chlorine gas is thus described by Dr. Henry :—

" Metallic antimony burns with a very brilliant white flame, and throws out sparks. Arsenic exhibits a fine green or blue flame, attended with sparks and a dense white smoke. Bismuth gives out a bluish flame. Nickel a yellowish white one. Zinc a white flame, and sparks. Tin a bluish white light. Lead a clear white flame.

Copper a red and slowly spreading light; and iron a bright red light. In all these experiments, the temperature of the gas should not be so low as 70°."

CONVERSATION IV.

Of the Combustible Acids.—Of the Acetic, Benzoic, Succinic, Camphoric, and Oxalic Acids.

TUTOR. The next class of acids are called *combustible;* they were formerly denominated vegetable and animal acids, because they are almost all procured from the animal and vegetable kingdom.

James. Do they differ much from the others ?

Tutor. They all contain at least two simple combustibles ; whereas the others only contain one.

Charles. What are these two substances ?

Tutor. Carbon and hydrogen ; some of them contain likewise azote, or nitrogen.

James. Do they possess no oxygen ?

Tutor. Some of them contain a considerable quantity, but others are destitute of it altogether.

Charles. Are they named according to the proportion of oxygen which they contain?

Tutor. As none of them are saturated with oxygen, the terminations of *ic* and *ous* are not used to indicate the proportion of oxygen which they contain. On that account Dr. Thomson makes them all terminate in *ic*, as acetic, benzoic acid, &c.

James. I think I have heard of acet*ous* acid.

Tutor. Chemists still make the distinction, with regard to this particular acid. They are divided by Dr. Thomson into four classes, or orders.

Charles. How are they distinguished?

Tutor. The *first class* are crystallizable and volatilizable: these are,

1. Acetic	compounded of	Carbon,
2. Benzoic		Hydrogen,
3. Succinic		and
4. Camphoric		Oxygen.

The *second class* are crystallizable but not volatilizable; these are,

1. Oxalic	compounded of	Carbon,
2. Mellitic		Hydrogen,
3. Tartaric		and
4. Citric		Oxygen.
5. Sebacic		
6. Saclactic		
7. Laccic		

The *third class* are not crystallizable; these are,

1. Malic	compounded of	Carbon,
2. Lactic		Hydrogen, and
3. Suberic		Oxygen.

The *fourth class* are called anomalous, *viz.*

1. Gallic	compounded of	Carbon, hydrogen, oxygen.
2. Prussic		Carbon, hydrogen, azote.
3. Sulphuretted hydrogen		Sulphur, hydrogen.

James. I see the component parts of all the acids in the three first classes are the same; what then makes the difference between them?

Tutor. That depends on the several proportions of the same ingredients. We shall now describe the ACETIC acid, as the most important and useful of this class of acids.

Charles. Is not that distilled vinegar?

Tutor. This acid is employed in three different states: the *first* is simple vinegar; the *second* is that purified by distillation, called either distilled vinegar, or, by chemists, acetous acid; and, when it is concentrated as much as possible, it is named radical vinegar, or acetic acid.

James. I think I have seen wine and beer placed in the garden, from which vinegar was produced.

Tutor. It may be obtained by exposing to the warm atmosphere any fermented liquor. It requires, however, hot weather, as well as the constant access of the atmosphere.

Charles. Does it imbibe the oxygen from the air?

Tutor. That is undoubtedly the principle of acidity in this case. Vinegar thus obtained is far from being pure ; but, being distilled, the impurities are left behind, and the product is colourless as water. In this state it is the acetous acid of the shops.

Charles. How are the fluids distilled ?

Tutor. Distillation on a large scale is performed in an apparatus exhibited in Fig. 10. A is the body of the still, which, when large enough to require it, is set in brick work ; the fire is applied underneath. B is the head of the still, provided with an aperture *z*, to let off superfluous vapours ; *b* is designed for the purpose of supplying the still with fluid. C is called the refrigeratory, or condensing tub, filled with cold water, and its worm is represented by dotted lines. D is a vessel to receive the distilled fluids passing through the worm. Fig. 11 is a copper vessel for distilling in a water bath. It fits into the mouth of the still, and the same head serves for both.

James. How is it obtained in that state in which it is denominated acetic acid ?

Tutor. When exposed to the frost a part of it congeals ; this consists almost wholly of water, which may then be easily separated ; the rest is the acid in a high degree of concentration.

Charles. Will the acid freeze ?

Tutor. Not by any frost that we had ; but by reducing it, by artificial means, to a temperature of about 50° below the freezing point, it crystallizes into ice.

James. Does this acid unite with the alkalies, earths, and oxydes ?

Tutor. It does, and the compounds are called acetates. In this state it is very pungent ; and, if applied to the skin, it reddens and corrodes in a short time.

Charles. Does it act upon the metals ?

Tutor. Yes : it is capable of oxydizing iron, zinc, copper &c. ; but several of the others, as gold, silver, platina, and mercury are not affected by it. When distilled with alcohol, it affords an acetic ether.

James. What is the BENZOIC acid ?

Tutor. It is a very fine, light, and whitish powder, obtained from benzoin, a resin much used in pharmacy. It combines with alkalies, earths, and metallic oxydes, and the compounds are benzoates.

Charles. Are the flowers of benzoin, which are a very white, shining and silky sort of powder, the same thing as benzoic acid.

Tutor. They are, and may be obtained from the resin by exposing it, in a crucible, to a gentle heat, and covering the crucible with a cone of paper ; the acid will sublime and be attached to the paper.

Charles. Does it dissolve in water ?

Tutor. It does in boiling water, and also in alcohol ; but in the latter case, by the addition of water, it is instantly precipitated from the spirit.

James. What is SUCCINIC acid ?

Tutor. It is obtained from amber, and it derives its name from *succinum*, the Latin word for that substance. The succinic acid takes the form of crystals, white, shining, and transparent ; they have an acid taste, and redden the tincture of turnsole.

James. Are these crystals soluble in water ?

Tutor. In boiling water and alcohol they may be dissolved, but as the liquids cool the crystals shoot out again. The compounds resulting from this acid, with the alkalies, earths, and metallic oxydes, are called succinates.

Charles. Are any of these compounds of much use ?

Tutor. The most important is the succinate of ammonia. This salt decomposes all the solutions of iron, and affords an insoluble precipitate, which is useful in the analysis of mineral waters.

Charles. The CAMPHORIC acid is, you told us before, in the shape of crystals.

Tutor. They are in the form of parallelopipedons, but of so delicate a texture that they effloresce in the air. These are of a slightly acid taste, and they redden vegetable colours.

James. How is this acid obtained ?

Tutor. By distilling camphor with nitric acid. It forms camphorates with alkalies, earths, and metallic oxydes.

Charles. What is the OXALIC acid ?

Tutor. It is found in the juice of sorrel, *oxalis acetosella*, and from thence it derives its name : but it is obtained in quantities from sugar.

Charles. By what means ?

Tutor. It requires the addition of nitric acid, which causes an effervescence. Nitrous gas flies off, the oxygen combines with the sugar and forms crystals, which have the following characteristics ; they have a strong acid taste, and act on vegetable colours ; they dissolve in twice their weight of water ; and they effloresce in the air.

James. Do the alkalies, earths, and oxydes, combine with the oxalic acid ?

Tutor. Yes : and the compounds are called oxalates.

Charles. Does this acid act upon the metals ?

Tutor. It is capable of oxydizing lead, copper, iron, and the semi-metals ; but it has no effect on gold, silver, platina, or mercury. The attraction which it has for iron causes it to be employed in taking ink spots from linen. It is also much used by calico printers ; and it detects most readily the existence of lime held in solution.

James. How is that done ?

Tutor. A little of the pure acid, or of the solution of oxalate of ammonia, is dropt into the liquid supposed to contain lime ; and, if there be any, a white powder is immediately precipitated. We shall proceed with the remaining acids to-morrow.

CONVERSATION V.

Of the Mellitic, Tartaric, Citric, Sebacic, Saclactic, Laccic, Malic, Lactic, Suberic, Gallic, and Prussic Acids.

TUTOR. MELLITIC acid is not derived from honey, as you would imagine by the name ; but from *mellite*, or honey-stone, a mineral found in some parts of Germany.

Charles. How is the acid obtained ?

Tutor. By reducing the mineral to powder, and boiling it in water : the acid combines with the water, which, being evaporated, fine crystals are formed in the shape of needles. The compounds resulting from this acid, with earths, alkalies, and metallic oxydes, are called *mellates.*

James. What is TARTARIC acid ?

Tutor. It is obtained from the common cream of tartar, as it is called : this is procured from casks in which wine has been kept. This acid is found in the form of crystals, which readily dissolve in water.

Charles. Is it capable of oxydizing the metals?

Tutor. It acts upon iron, zinc, and even mercury; but not upon the finer metals, nor upon the semi-metals. It combines with the alkalies, earths, and metallic oxydes, forming with them salts, called *tartrates.* This acid is scarcely used: but some of the compounds are employed in medicine.

CITRIC acid, as its name denotes, is obtained from the juice of lemons and oranges. It crystallizes in beautiful prisms, is extremely acid, and very soluble in water.

James. Will it combine with the alkalies?

Tutor. Yes: and also with the earths and metallic oxydes, forming salts, denominated citrates.

Charles. This acid is much used, I believe, in domestic concerns.

Tutor. It is: and also in medicine, being the base of what are called saline draughts. It has been asserted, that the largest dose of laudanum may be checked in its narcotic effects, if a proper quantity of citric acid be taken with it; and that, in these circumstances, it excites cheerfulness, succeeded by refreshing sleep, instead of stupefaction.

James. What is meant by SEBACIC acid?

Tutor. The word is derived from *sebum*, the Latin word for fat; and sebacic acid is the acid obtained from fat, or suet.

Charles. I should not have supposed that fat contained any thing like an acid.

Tutor. The fact is, however, certain: this acid has scarcely any smell and but little taste.

It reddens the tincture of turnsole. When heated it melts like tallow: it is soluble in water, particularly in hot water.

James. Does it ever appear in crystals?

Tutor. It may be obtained in that state, and, by proper precautions, in large and very brilliant plates. This acid combines with the alkalies, earths, and oxydes, and forms with them salts, called *sebates.*

Another acid mentioned by chemists is *saclactic.*

Charles. What does that word mean?

Tutor. The word is compounded of *sac*, for *saccharum*, *sugar*, and *lac milk:* the acid therefore is that obtained from the sugar that is found in milk. This acid is got in the form of a gritty powder, which may be crystallized: the solution has an acid taste, and reddens the infusion of turnsole.

James. Does it combine with the earths, alkalies, and oxydes?

Tutor. Yes: and the compounds are salts, called *saccolates*, of which little is at present known.

Charles. There is also a LACCIC acid; from what is that obtained?

Tutor. From a substance called white lac, which is produced by an insect of the coccus genus. This substance is not very unlike beeswax. The acid obtained from it changes the paper stained with turnsole to a red colour, and place where it was discovered. The acid is colourless liquid, like water, and does not alter the colour of vegetable blues. Having gone through the principal acids, for there are some others which we shall not now enumerate, can you tell me what the properties are that characterize acid bodies?

Charles. They almost all have, 1. an acid taste; 2. the power of converting vegetable blues to red; 3. they are soluble in water; and, 4. they have the property of forming salts.

Tutor. Do you recollect into what classes we have divided them?

James. Into three classes:—1. those that are formed by combustion, and which are called products of combustion; 2. the supporters of combustion; and, 3. those that are combustible.

Tutor. Do you know what is esteemed essential to acidity?

Charles. Oxygen to the *products* and *supporters;* and it enters into the composition of almost all the combustible acids.

Tutor. How many ingredients enter into the composition of the acids?

James. In the products and supporters of combustion only two, *viz.* the base and oxygen. Thus sulphuric acid is a compound of oxygen and sulphur. But in the combustibles there are three or more, *viz.* oxygen, hydrogen, and carbon.

Tutor. Of the proportional parts of these ingredients in the different acids, little is known except of three, which are formed by the following proportions, or nearly so :—

Acids.	Oxygen.	Carbon.	Hydrogen.
Acetic	50.19	35.87	11.94
Oxalic	77.00	13.00	10.00
Tartaric	70.50	18.00	10.05

CONVERSATION VI.

Of Iodine, and its Compounds.

TUTOR. I have now to mention to you a new substance in Chemistry, which was discovered so lately as the year 1812: it is denominated *iode*, by the French, to whom we are indebted for it; by the English it is called *iodine*.

James. Is it of the same kind with potassium and sodium, the newly discovered metals of Sir Humphrey Davy?

Tutor. No; it is thought to be a new simple supporter of combustion, capable, like oxygen, of combining with almost all the combustible bodies, and of forming therewith various acids and genera of salts, hitherto unknown: of course it is regarded as a very important addition to the science of Chemistry.

Charles. By whom was this substance discovered?

Tutor. By M. Courtois, a manufacturer of *saltpetre* at Paris, in the following manner:—In the processes for procuring soda from the ashes of seaweeds, he found his metallic vessels corroded; and, in his attempt to ascertain the cause, he made the discovery of *iodine.*

James. From whence did he derive the name of his new substance?

Tutor. From the violet colour of its vapour. Gay Lussac gave it the name *ione*, from the Greek, ιον, a violet; but Sir Humphrey Davy, conceiving the term liable to ambiguity, proposed that of *iodine*, from, ιωδης, *violet-coloured*, which term, either in the English or French form, is now generally adopted.

Charles. It is something like the new name *chlorine.*

Tutor. It being analogous to the terms *chlorine* and *oxygen*, the names of the other two supporters of combustion, probably led to its adoption.

James. Did M. Courtois complete his discovery by fully investigating the nature of his new substance?

Tutor. No: he had not leisure to prosecute the experiments for the purpose, though, at first, he undoubtedly meant to do so; and, on that account, for a time, he concealed the discovery. At length, finding his manufacturing concerns would not allow him time for the purpose, he gave it up to M. Clement, who in his turn abandoned it to Gay Lussac, one of the most active and well informed chemists of the present age. This gentleman speedily determined, that iodine was a new undecompounded substance; and in the month of August, 1814, read, to the Natio al Institute, an elaborate memoir on the subje

Charles. How is iodine obtained?

Tutor. Many methods have been already described; the following is very intelligible, an will answer our end as a description :—Th kelp, or other marine plant, is boiled or steeped in hot water, till every thing soluble i taken up: this saline liquor is separated fro the insoluble portion of the kelp, by means o a filter, and concentrated by evaporation, til all the salts, which it is disposed to yield, hav been deposited. The residual liquor is no to be mixed with a quantity of sulphuric acid sufficient to render it distinctly acid; and th mixture, after being boiled for some time, i an open vessel, is to be filtered through wool Mix the filtered liquid with a quantity of blac oxyde of manganese, in powder, equal in weigh to the sulphuric acid originally added to it.— Put the mixture into a glass flask, and expos it to heat. A violet-coloured vapour speedil arises, which is to be received into a glass vessel, in which it is condensed, and constitute the iodine.

James. In what form does it appear?

Tutor. In the shape of crystalline plates, having the aspect of plumbago.

Charles. What are its principal properties?

Tutor. Iodine is a solid, at the common temperature of the atmosphere: it is often in scales resembling those of micaceous ore; sometime in large brilliant rhomboidal plates, and sometimes these are in elongated octohedrons. In colour it is of a bluish black. Its lustre is metallic; it is soft and friable, and may be easily rubbed into powder. Its taste is very acrid, and it is so sparingly soluble in water that not more than the 7000th part can be taken up by that fluid. Its specific gravity is almost [illegible] times greater than that of water. It is a non-conductor of electricity, and possesses, in a high degree, the electrical properties of oxygen and chlorine (see Conversation III.), being determined to the positive pole of a galvanic arrangement. When applied to the skin it produces a yellow stain, which disappears as the iodine evaporates.

Charles. Is it fusible like the metals?

Tutor. It is fusible at a degree of heat a little higher than boiling water, and is volatilized at the temperature of [illegible] forming a gas 118 times heavier than [illegible]. When distilled with water, [illegible] the heat of boiling water [illegible] its affinity for aqueous vapour [illegible] the vapour, in this case, [illegible] whence, as we have seen [illegible]

James. Have iodine and oxygen [illegible] upon each other?

Tutor. Iodine undergoes no change [illegible] heated in oxygen gas [illegible] of euchlorine, it may be combined with [illegible] and then it furnishes a peculiar acid with that body.

Charles. What effect is produced by its being brought into contact with nitrogen?

Tutor. Nitrogen, or azotic gas, of itself, has no action on iodine; but, when it is added to liquid ammonia, one part of it unites with the hydrogen of the alkali, and forms what is called *hydriodic* acid, while another portion of the iodine combines with the nitrogen, and falls down in the form of a black powder. This compound of iodine and nitrogen detonates with a very moderate heat, and even with the slightest touch.

The affinity of iodine for hydrogen is very strong, and it absorbs that base from hydrogen gas, and detaches it from several of its combinations, affording, as the result, a distinct acid.

James. How is the combination effected?

Tutor. If iodine be heated in dry hydrogen gas, an expansion of its volume takes place: an acid gas is formed, which is very absorbable by water, and acts so much on mercury, that it cannot be preserved long over that metal. A similar gaseous compound is formed by exposing iodine to sulphuretted hydrogen gas.

Charles. Do you mean, that mercury and iodine combine and form a compound?

Tutor. I do: for no sooner does the gas come into contact with the metal, than it begins to be decomposed; the iodine unites with the mercury: and there remains, after the combination is completely formed, a volume of hydrogen gas, equal exactly to half that of the acid gas.

James. Do any of the other metals have an action upon this acid gas?

Tutor. It is decomposed, in a similar manner, by all the metals, excepting gold and platina. If the acid gas is heated in contact with oxygen gas, it is immediately decomposed; the oxygen seizing upon the hydrogen. Chlorine, also, instantly deprives it of hydrogen, and produces muriatic acid gas, and the iodine re-appears in the form of a beautiful violet-coloured vapour.

Charles. What is this acid gas called?

Tutor. It is named *hydriodic acid gas*, and its specific gravity is more than four times heavier than the common atmospheric air: it is plentifully absorbed by water, and the solution is fuming with the specific gravity of 1.7. To prepare this liquid, put powdered iodine in water, and pass sulphurated hydrogen through the mixture. The hydrogen unites with the iodine, and the sulphur is precipitated.

The liquid acid is slowly decomposed, by contact with the air: its hydrogen being attracted by the oxygen of the atmosphere and a portion of the iodine is liberated.

Concentrated sulphuric acid, nitric acid, and chlorine, decompose this acid gas, and separate the iodine from it. With solutions of lead, it gives a fine orange precipitate; with a solution of *per-oxyde of* mercury, a red one; and with *silver a white* precipitate is yielded.

James. Is this acid gas decomposed by means of the Galvanic electricity?

Tutor. It is very rapidly decomposed when submitted to the action of a strong battery; the iodine appears at the positive, and hydrogen at the negative pole. It is decomposed by those oxydes, which hold their oxygen loosely, and combines with the rest, forming a genus of neutral salts called *hydriodates.*

Charles. Do sulphur and iodine unite?

Tutor. They do, at a gentle heat, and a black radiated compound is formed, resembling sulphuret of antimony. This may be readily decomposed by a degree of heat a little higher than that at which it was formed, and the iodine is detached in vapour.

Phosphorus and iodine likewise combine at the temperature of the atmosphere, evolving heat, but no light; the result is a phosphuret of iodine, of a reddish brown colour, the solidity, fusibility, and volatility of which vary with the proportions of its ingredients.

James. What effect has potassium upon iodine?

Tutor. Potassium burns in the vapour of iodine, with a pale blue light, without giving out any gas. The substance produced is white, fusible at a red heat, and soluble in water. To this substance Sir Humphrey Davy has given the *name of iode of potassium*, the term iode being *a generic* one for the compounds of iodine, and the metals and other combustible bases ; but Gay Lussac makes use of the name iodure or ioduret.

When iode or ioduret of potassium, silver, mercury, or lead, is heated in chlorine gas, the iodine is expelled, which proves, that the affinity of chlorine, for those metals, surpasses that of the iodine.

Charles. Have the alkalies themselves an affinity for iodine ?

Tutor. When iodine, in a state of vapour, is passed over ignited *hydrate* of potass, oxygen is disengaged, and a compound is formed similar to that which results from the combination of iodine and potassium. Hence it is inferred, that the affinity of iodine for potassium exceeds that of oxygen, and the same may be said of several other metals.

James. What do you mean by the term *hydrate ?*

Tutor. Water enters into combination with various solid bodies, and in the union entirely loses its fluid form. Such compounds are denominated *hydrates.* The pure alkalies, potass and soda, retain, for example, even after fusion, about one fifth their weight of water, which can only be separated by some body having a stronger affinity for the alkali than the water.

Charles. Do iodine and chlorine unite ?

Tutor. Iodine absorbs about one third of its weight of chlorine, and forms, with it, a peculiar acid, called *chloriode* or *chloriodic acid*, and its compounds *chloriodates.*

When iodine is exposed to euchlorine, there is an immediate action, its colour is changed to a bright orange, and a liquid is formed.

James. Is it generally admitted, that iodine is a simple or elementary substance?

Tutor. It is; for it has never been decomposed; it bears a striking analogy with chlorine, which it resembles, 1st. In forming one acid by uniting with hydrogen, and a different acid with oxygen; 2dly. In its effects on vegetable colours; 3dly. In its affording, with fixed alkalies, salts that nearly approach in character to the hyperoxymuriates; and, 4thly. In its electrical habitudes.

The discovery of this substance, says Dr. Henry, "lends a strong support to that theory, which considers chlorine as a simple body, and muriatic acid as a compound of chlorine and hydrogen. In the property of forming an acid, whether it be united with hydrogen or with oxygen, iodine bears, also, an analogy to sulphur; it is remarked of the combinations of chlorine, iodine, and sulphur, with the elements of water, that, while the acids, which they form with oxygen, have their elements strongly condensed, those formed with hydrogen have their elements very feebly united. Sulphur has the strongest affinity for oxygen, then iodine, and lastly chlorine. But for hydrogen, chlorine has a stronger attraction than iodine, and iodine than sulphur."

James. What means is there of detecting this *new substance*, when present in other substances?

r. There are several modes : it has the
ty of corroding metals, especially of black-
silver more powerfully than any body at
t known. This property led to the origi-
covery in kelp ; and Sir Humphrey Davy
ed it as a method of detecting iodine in
ations of the ashes of different seaweeds.
n sulphuric acid is poured upon a dry salt
ing iodine, a reddish brown liquid is ob-
which is another method of detecting the
ce of iodine in salts. But the most deli-
-agent for iodine is *starch*. When this
ce is put into a liquid containing iodine in
of liberty, it detects the presence of so
quantity as the $\frac{1}{450000}$ th part, by the blue
which it forms.

CONVERSATION VII.

Of the Metals.

TUTOR. Metals are opaque and combustible; they have a lustre peculiar to themselves, and are fusible, but insoluble in water. Their specific gravity is greater than that of any other simple body ; and they are all conductors of caloric and electricity. Some of them are malleable ; and some of them are very ductile, or capable of being drawn into very fine wire.

Charles. How many metals are there ?

Tutor. Dr. Thomson reckons 23, but some other chemists mention 28 : we shall follow Dr. Thomson, who arranges them under three classes, *viz.*—1. The malleable ; 2. The brittle and easily fusible ; 3. The brittle and difficultly fusible : according to the following

TABLE OF METALS.

CLASS I.

MALLEABLE.

1. Gold
2. Platinum
3. Silver
4. Mercury
5. Copper
6. Iron
7. Tin
8. Lead
9. Nickel
10. Zinc.

CLASS II.

BRITTLE AND EASILY FUSED.

1. Bismuth
2. Tellurium
3. Antimony
4. Arsenic.

CLASS III.

BRITTLE AND DIFFICULTLY FUSIBLE.

1. Cobalt
2. Manganese
3. Tungsten
4. Molybdenum
5. Uranium
6. Titanium
7. Chromium
8. Columbium
9. Tantalium, and
10. Cerium.

James. How do you reckon mercury among the malleable metals?

Tutor. Because this property belongs to it when it is frozen.

James. Were not some of the metals formerly compared with the sun and planets?

Tutor. The ancients gave to the seven metals, with which they were acquainted, the names of the sun and planets then known: the marks, which denoted the planets, when speaking on the subject of astronomy, denoted also the metals, when treating of the other departments of natural knowledge: thus

GOLD was the	SUN, represented by	☉
SILVER	MOON,	☽
MERCURY	MERCURY,	☿
COPPER	VENUS,	♀
IRON	MARS,	♂
TIN	JUPITER,	♃
LEAD	SATURN,	♄

James. Here is no character, or metal, represented by the earth.

Tutor. The earth was not then considered as a planet; and the moon, which was at that time regarded as a planet, is now known to be only an attendant upon the earth.

Charles. Where are the metals to be met with?

Tutor. They are found in the bowels of the earth; but not in the state which renders them useful to us. Iron, for instance, the most useful and important of all metals, is not found in the earth in bars, but in the appearance of a stone: this is called an ore: it is the metal combined with sulphur, oxygen, clay, or other extraneous *substances.* Here is a specimen of iron ore.

Charles. In what countries are they found?

Tutor. In almost every part of the world some or other of the metals are obtained; generally in mountainous countries, in the crevices of rocks, forming what are called veins of ore. The metallic matter of ores is generally incrusted and intermingled with some other substance, different from the rock in which the vein is situated: this substance is termed the *matrix.*

James. Are all the metals found in the state of ores?

Tutor. Gold and silver, and sometimes copper, are obtained in a state of purity. But the other metals are usually found, as ores, blended with other substances, so as not to have the ductility or other qualities of metals?

James. How are metals obtained from the ores?

Tutor. By various methods, as will be described when we treat of them separately; such as washing, roasting, fusion, &c.

Charles. I understand the object of fusion: but what is intended by washing and roasting the ores, as you term the operations, I cannot conceive.

Tutor. By washing the ore, after it is reduced to powder, it is purified from whatever salts, or other matters, soluble in water, that may be attached to it. By roasting, sulphur, arsenic, and other such matters are dissipated, which, if fused with the metal, would be highly injurious to it. Wrought iron, in which there is any portion of sulphur, is very brittle and almost useless.

James. What is the cause of iron becoming rusty, and the other metals tarnished?

Tutor. Almost all metals, when exposed to the action of heat and the air, lose their lustre; and in length of time are converted into earthy-like powders, of different colours and properties; such is the rust of iron. These powders are called oxydes: because they are the metals combined with oxygen, which they absorb from the atmosphere, water, &c.

Charles. Are all the metals capable of combining with oxygen?

Tutor. Yes: and sometimes the combination is accompanied with combustion, and sometimes not. Frequently the metal is first found as a pure oxyde, which, to be reduced to the metallic state, requires nothing more than that the oxygen should be driven from it: such are iron ochres, which are the oxydes of iron.

James. Will the metals unite with the earths and alkalies?

Tutor. Not in their metallic state and by fusion: but they most of them may be first reduced to oxydes, and then they will readily combine with the acids, earths, and alkalies.

James. You have told us already, that there are sometimes two or more oxydes of the same metal, which differ in their colours and other qualities, according to the quantities of oxygen absorbed; pray how are they distinguished from each other?

Tutor. Here again I refer you to Dr. Thomson's system, which, from its superior excellence, will probably be the standard work in Chemistry; this gentleman uses the term *oxyde* to denote the combination of metals with oxygen in general: *protoxyde* is the *first* oxyde, which the metal is capable of forming.

Charles. Do you mean an oxyde with the least possible quantity of oxygen?

Tutor. I do: *deutoxyde* will denote a metal combined with two doses of oxygen; *tritoxyde* will show, that the metal has combined with three doses of oxygen; and *peroxyde* will denote an oxyde combined with a maximum of oxygen.

James. I comprehend this: *protoxyde* and *peroxyde* denote the minimum and maximum of oxydizement, and the terms *deutoxyde*, *tritoxyde*, &c., denote all the intermediate states in which the oxydes are capable of being formed.

Charles. Do not the metals combine readily with one another?

Tutor. They do, and thus form very useful compounds. Thus, pewter is a compound of lead and tin; brass is a compound of copper and zinc; bell metal is a compound of copper and tin. The compounds are called *alloys*, except when one of the combining metals is mercury; and in that case the compound is called an amalgam.

James. Is the amalgam used in electricity called the amalgam of tin?

Tutor. It is: and one formed of mercury and gold would be called the amalgam of gold : mercury, being common to them all, is never used as a name to any.

Charles. Are there not some metallic bodies denominated semi-metals ?

Tutor. If you refer to the table, which I gave you just now, you will see the first class consisted of malleable substances ; they are most of them likewise more or less ductile, and, perhaps, on account of these properties, they were called METALS ; but the substances in the other classes, being brittle, were denominated *semi-metals.* This distinction is now generally out of use. We shall to-morrow proceed with the metals separately, beginning with GOLD.

CONVERSATION VIII.

Gold, *Platinum* (Rhodium, Palladium, Iridium, and Osmium.)

TUTOR. Gold is reckoned the most valuable of all the metals : it is not the least altered by being exposed to the air, neither has water the smallest action upon it.

Charles. I believe it is not easily melted.

Tutor. Not by the heat of our fires : but by means of a furnace it is fused without difficulty : it may even be volatilized. When melted it assumes a bluish green colour. Its specific gravity is more than nineteen times greater than that of water.

James. Is it not very ductile ?

Tutor. It is ; and malleable too, more so than any other metal.* A wire of gold, only one tenth of an inch in diameter, will sustain more than 5 cwt.

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* *See Scientific* Dialogues, vol. 1, p. 14.

Gold, as we have observed before, can be solved in the nitro-muriatic acid.

Charles. Did you not say, that no metal is s ble in acids till it had been reduced to the s of an oxyde ?

Tutor. I did ; and this process is thus expl ed. The nitro-muriatic acid consists of e parts of the nitric and muriatic acids. The a strong affinity between the oxyde of gold muriatic acid. The nitric acid furnishes ox to the gold, and the muriatic acid dissolves oxyde as soon as it is formed.

James. Then it becomes a salt, *viz.* the m ate of gold.

Tutor. It does : but an oxyde may be ob ed by combustion, either by Galvanism, ele city, or by means of a very powerful bur glass.

Charles. Is there only one oxyde of gold

Tutor. Yes : there are two, the protoxy a purple colour, and the peroxyde of a ye colour. The oxydes may be decompose close vessels by the application of heat. gold remains fixed, and the oxygen assumes form of gas. They may be decomposed als the several substances, which have a stro affinity for oxygen than gold has.

James. With what substances will gold bine ?

Tutor. With a great number of metals, ar forms with them a variety of alloys. It will bine also with phosphorus, making with phosphoret of gold, which is brittle, whitish, and has a crystallized appearance.

Experiment 1. A thin sheet of gold introduced into oxygenized muriatic acid, when in a gaseous state, will take fire and burn.

Ex. 2. The nitro-muriate of gold in solution gives a purple hue to the skin : it is also used for staining ivory, feathers, porcelain, &c. Even marble may be died with it.

Ex. 3. The oxyde of gold, combined with ammonia, makes fulminating gold, which explodes with great violence by means of heat.

Charles. How is this fulmination accounted for ?

Tutor. The ammonia is a compound of hydrogen and azote ; the hydrogen unites with the oxygen of the oxyde, which reduces the gold to a metallic state, while the azotic gas, and perhaps aqueous vapour, are liberated in a highly expanded state. The impulse of these aeriform products on the atmosphere appears to be the cause of the loud noise occasioned by the explosion of this compound.

Ex. 4. Ribands, &c., moistened with the diluted solution of gold, and exposed to a current of hydrogen gas, obtained from iron filings and sulphuric acid, will be gilt. Of course it is easy, by means of a camel's hair brush, to exhibit regular figures in gold upon them.

Ex. 5. A sheet of tin, immersed in a solution of nitro-muriate of gold, precipitates the gold of a purple colour, which, when collecte forms a powder much employed in enamelling.

Ex. 6. If ether be added to a solution of m riate of gold, the gold will leave the acid a float on its surface, combined with the ether.

Ex. 7. Gold, which is too soft in its pure sta for many purposes, has its hardness increased b being melted, or alloyed, with a small proporti of copper.

Charles. Are gold coins and medals alloys gold and copper ?

Tutor. They are : and in all cases the degre of purity of the gold is expressed by the numb of parts of that metal contained in twenty-fo parts of any mixture. Thus gold, which in twen ty-four such parts, called carats, contains twe ty-two of pure metal, is said to be twenty-tw carats fine.

James. How is absolutely pure gold expresse

Tutor. It is called twenty-four carats fine.

It is a singular fact, that some kinds of coppe which are not in the least defective as coppe totally destroy the ductility of gold.

Charles. How is that accounted for ?

Tutor. It is probably owing to its contamin tion with lead or antimony, of either of whic metals only $\frac{1}{1920}$th in weight is sufficient to pr duce this effect.

James. Where does gold chiefly come from

Tutor. It is sometimes found in the ores other metals ; but it abounds in the sands many rivers in Africa, America, and India.

always occurs in a metallic state, and commonly in the form of grains.(*a*)

Charles. What is this white and very heavy metal?

Tutor. It is PLATINUM; it is by much the heaviest of all the metals, being, when hammered, twenty-three times heavier than water. Like gold, it is exceedingly ductile and malleable, and is the most infusible of all metals.

James. How is it melted?

Tutor. By means of the blow-pipe (see volume i,) with the assistance of oxygen gas.(*a*) This metal is not in the smallest degree affected by the action of air and water. It has the property of *welding*, which belongs to no other metal than this and iron.*

Charles. What does welding mean?

Tutor. Two pieces of wrought iron, raised to a white heat, may be permanently united by forging; this is called welding.

James. We saw the operation in the formation of anchors at Portsmouth.

Tutor. Right: and it may be seen, in a small way, at almost any smith's forge.

Charles. Can platinum be oxydized?

Tutor. Not by the strongest artificial heat that can be applied; but it may by boiling it in sixteen times its weight of nitro-muriatic acid. By the addition of lime, a yellow powder will fall to the bottom, which is the oxyde of platinum.

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* *This property is found* to belong to the newly discovered metals potassium and sodium.

James. Will platinum combine with the other metals?

Tutor. It will, and forms alloys with them. If it could be readily and cheaply obtained, it would form very precious vessels, as they could not be acted upon by many bodies, and might be exposed to the greatest heat without alteration.

James. By what is platinum acted upon?

Tutor. By fusion with nitrate of potass, and also with pure fixed alkalies. This diminishes its utility in some respects.

Charles. Is it brought at all into use?

Tutor. Crucibles and spoons are made of it for chemical purposes, excepting where alkalies are to be fused. It is also used in the manufacture of specula for telescopes.

Charles. What test is used to discover the presence of platinum in other substances?

Tutor. The most delicate test of the presence of platinum is the muriate of tin. A solution of platinum, so diluted as to be scarcely distinguishable from water, assumes a bright red colour, on the addition of a single drop of a newly made solution of tin.

James. With which of the metals does platinum combine?

Tutor. It combines with the newly discovered metals potassium and sodium, and affords brittle compounds. It unites with most of the metals. In the proportion of one sixteenth it renders gold pale: it amalgamates with mercury, and diminishes the fusibility of fusible metals.

It is a remarkably slow and bad conductor of heat.

Charles. What experiment proves this?

Tutor. When equal pieces of silver, copper, and platinum were covered with wax and heated at one end, the wax was melted 3¼ inches on the silver, 2½ on the copper, and 1 inch only on the platinum.

James. Where is platinum found?

Tutor. It is obtained in grains, in a metallic state, at St. Domingo, and in some parts of Peru.

Connected with platinum, we must briefly notice four other newly discovered metals, though they do not all come under the class of malleable metals. These are named Rhodium, Palladium, Iridium, and Osmium.

Charles. Why are they mentioned in connexion with platinum?

Tutor. Because they are separated from the ore of platinum.

James. What are the properties attached to RHODIUM.

Tutor. It is not malleable: its specific gravity is 11, and it unites with all the metals, that have been tried, except mercury. When alloyed with three times its weight of bismuth, copper, or lead, these alloys may be completely dissolved in a mixture of two parts, by measure, of muriatic acid, and one of nitric. When lead is used, it is reduced by evaporation to an insoluble muriate, which then exhibits the rose colour, from which circumstance the name of the metal is derived. It is soluble in alcohol.

Charles. Is PALLADIUM also obtained from the ore of platinum?

Tutor. It is: and it is very like platinum, only of a duller white: it is malleable and ductile, and its specific gravity is from 11 to 11.5. The true solvent of this metal is nitro-muriatic acid, which acts upon it with violence, and yields a beautiful red solution.

James. Can it be readily precipitated from the solution?

Tutor. Yes; precipitates may be produced by alkalies and earths, which are of a fine orange colour. Palladium readily combines with other metals; and it has the property, in common with platinum, of destroying the colour of gold, even when used in the very small proportion of one to five or six.

Charles. Are the other two metals obtained also from the ore of platinum?

Tutor. Yes, both iridium and osmium have been separated from that ore, in the state of oxydes.

IRIDIUM was so named from the variety of colours exhibited in the oxyde. It has been obtained in a state of purity by heating the muriate, which expelled the acid and oxygen. It is of a white colour, and perfectly infusible.

OSMIUM, in a state of oxyde, has a peculiar and *pungent* smell, something resembling that of chlorine gas, whence it had its name. The pure metal forms with gold and silver malleable alloys.

The most striking test of the oxyde of osmium is an infusion of galls, which soon becomes of a purple colour, and afterwards changes to a vivid blue exposed to the direct rays of the sun, its colour becomes darker. If fused by a gentle heat, it forms a semi-transparent mass, of the consistence of horn, called luna cornea.

Ex. 2. If one part of muriate of silver be mixed with three of carbonate of soda, and fused in a crucible, the silver will, when cold, be found reduced at the bottom of the crucible.

Ex. 3. A solution of nitrate of silver stains animal substances of a deep black; it has been applied to the staining of the human hair.—White paper, when stained with a solution of nitrate of silver, in the proportion of ten parts of water and one of the salt, exposed to the light, acquires colour, and passes through all the changes to black.

Ex. 4. Let a slip of ivory be immersed in a solution of pure nitrate of silver, till it has acquired a bright yellow colour: then remove it into a glass of distilled water, and expose it to the direct light of the sun; it will, after two or three hours, become black, but, on rubbing it a little, the surface will be changed into a bright metallic one.

Ex. 5. Nitrate of silver is decomposed by other metals: a plate of copper, to which it is applied, becomes plated with silver.

Spread a few drops of nitrate of silver upon a smooth piece of glass by means of a camel's hair brush; at the bottom of it, in contact with the fluid, place a small brass or copper wire, let it remain undisturbed, and in a short period it will begin to shoot out into apparent vegetation. It may perhaps require a magnifying glass to see it.

James. How is this explained?

Tutor. It is produced by the superior attraction of the copper for nitric acid to that of silver. The acid leaving the silver, it returns to the metallic state.(*a*) Upon this principle many articles are silvered over, as dial plates, the scales of barometers, &c.

Charles. Are they copper, washed over with the *nitrate* of silver?

Tutor. The muriate of silver is chiefly used; from which the silver is precipitated, and unites with the coppery surface.

James. Is that called *plating?*

Tutor. Copper is plated by first fastening, by means of borax, a plate of silver on an ingot of copper; in this state the ingot is rolled between steel rollers, till it is of the required thickness.

James. The silver of plating is very thin.

Tutor. Not more than the three-thousandth part of an inch thick.

A very useful solvent of silver is formed by dissolving one part of nitre by weight in eight or ten parts of concentrated sulphuric acid.—This compound, called nitro-sulphuric acid, when heated below the temperature of boiling water, dissolves a sixth or even a fifth of its weight of silver, with an extrication of nitrous gas, and leaves any copper or other metal with which the silver may be combined. Hence it is a most useful agent in extracting silver from old plated goods.

Charles. Can the silver be recovered from the solution again?

Tutor. It may, by adding to it muriate of soda, which forms muriate of silver, and this may be decomposed by carbonate of soda.

Ex. 6. If a little mercury be poured into a bottle, filled with this solution, and left some time undisturbed, the silver will be precipitated into a beautiful form, resembling the branches of a tree; this is called the arbor Dianæ.

Charles. Will you show me the experiment?

Tutor. Here is something more than three drams and a half of pure silver, and half as much mercury; I will dissolve them separately in sufficient quantities of pure nitric acid; then mix the solutions, and add to them five or six ounces of distilled water. This is to be poured upon rather less than half an ounce of an amalgam of silver, which is put into a spherical glass vessel. In the course of twenty-four hours, the silver tree will be formed.

James. Where is silver found?

Tutor. In various parts of the world, in a metallic state; and in the form of a sulphuret, a salt, and an oxyde.

Charles. Is there any method of knowing whether an ore contains silver?

Tutor. Yes: by reducing the ore to powder, and dissolving it in nitric acid, and afterwards adding a few drops of muriatic acid.

James. Will the nitric acid dissolve the silver, if there be any in the ore ?

Tutor. It will : and the muriatic acid will precipitate it in white flakes, as you saw was the case just now, when I added the muriatic acid to the nitrate of silver. There is often silver in ores, but in such small quantities as not to make it worth while to work for it.

CONVERSATION X.

Of Mercury.

TUTOR. I need not tell you, that this f shining substance is mercury ; it has derived veral names from its similarity to silver, as qui silver, argentum vivum, and hydrargyrum. I between thirteen and fourteen times heavier t water.

Charles. Does it not retain its fluid form, wh makes it so very unlike to the metals ?

Tutor. Yes, in our climate, the cold is ne so great as to render it solid ; but, by artifi means, it may, even here, be congealed, and t be made malleable and ductile.

James. Can it be made to boil like other quids ?

Tutor. Yes, and be changed to vapour, wh is invisible and elastic, like common air. Its el ticity may be increased so as to burst the stro est vessel that was ever made.

Charles. The surface of mercury soon tarnishes.

Tutor. When exposed to the air, it combines with the oxygen of it, and is thus converted into an oxyde. The change, however, goes on but slowly, unless aided by heat, or by agitation.

James. Can it be burnt, like gold and silver leaf, or wire?

Tutor. Dr. Thomson says he has never been able, by any method, to burn it; and that it is the only metal, which he has examined, that seems incapable of combustion.

James. Is it soluble in the acids?

Tutor. In nitric acid it may be dissolved, and nitrous gas disengaged; and, according as the solution is made with or without heat, a greater quantity of oxygen will be imbibed.

Charles. Will there then be more oxydes than one?

Tutor. There have been reckoned four: 1. The *protoxyde* is when the mercury is converted into a black powder by agitation, formerly called *ethiops per se.* 2. When it is dissolved without the assistance of heat, the *deutoxyde* is formed. 3. When exposed to the heat of 600°, it combines with more oxygen and becomes red; this is called the *tritoxyde*, which was formerly denominated *precipitate per se.* 4. If oxymuriatic gas is made to pass through the red oxyde of mercury, it combines with an additional dose of oxygen, and is converted into a *peroxyde.*

James. Does mercury combine with sulphur and phosphorus?

Tutor. Yes, most readily. If two parts of sulphur by weight, and one of mercury, be triturated together in a mortar, the mercury gradually disappears and the mass assumes a black colour. In this state it was formerly called *ethiops mineral;* but it is now found to contain mercury, sulphur, and sulphuretted hydrogen, and is on that account denominated *hydrogenous sulphuret of mercury.*

Charles. Where does the hydrogen come from in the operation?

Tutor. The sulphur imbibes it from the moisture of the atmosphere. If this substance is heated, part of the sulphur is dissipated, and the compound assumes a deep violet colour.

James. Is not vermillion, which makes a beautiful paint, a compound of mercury?

Tutor. It is composed of mercury and sulphur, united by fusion, and sublimed. It comes away in a fine cake, and in this state it was called *cinnabar;* and when reduced to powder it is denominated vermillion. It is the red *sulphuret of mercury.*

Charles. Is the mercury easily obtained from cinnabar?

Tutor. Yes, by decomposition. The mercury may be obtained in a state of purity, by mixing any quantity of the sulphuret of mercury with half its weight of iron filings, and then applying a heat to the retort in which the mixture is put.

James. The sulphuret consists of mercury and sulphur?

Tutor. True: the sulphur leaves the mercury and unites with the iron. The mercury is disengaged, and what is left in the retort is a sulphuret of iron.

The *phosphoret of mercury* is formed with phosphorus and the black oxyde of mercury, melted in a retort filled with hydrogen gas.

Charles. What effect has the hydrogen gas?

Tutor. It prevents the combustion of the phosphorus; this substance being formed of the oxyde, and not of the pure mercury, is called by Dr. Thomson *black phosphoretted oxyde of mercury.*

James. Mercury, I know, from a former Conversation, readily combines with several metals, making, with them, amalgams.

Tutor. The tin amalgam you have frequently seen; the amalgam of gold is formed very readily, by throwing small pieces of red hot gold into mercury, owing to the great affinity that these metals have for one another.

Charles. I once let a seven shilling piece fall into some mercury, and it came out white as silver.

Tutor. There was a real amalgamation of the metals, though, from the short time that the coin was in the mercury, it went no deeper than the surface.

Charles. By putting it into the fire, the mer-

cury was soon evaporated, and the money
good as ever.

James. I know you was sadly alarmed, lest
should thus have become good for nothing.

Tutor. By this little accident, you learn th
whole theory of gilding inferior metals. An ama
gam of about ten parts of mercury and one
gold, is spread upon the metal to be gilt; the
by the application of a gentle and equal heat, th
mercury is driven off, and the gold is left adh
ring to the surface. The surface is afterwar
rubbed with a brass wire brush under water, an
then burnished.

Charles. Is there silver amalgam?

Tutor. Yes: eight parts of mercury and on
of silver makes an amalgam of a white colou
and of a soft consistence. What is very remar
able in this is, that the specific gravity of th
composition is greater than the mean specific gr
vity of the two metals.

James. Can the mercury, in this case, be dr
ven off by heat?

Tutor. It may, and the silver remains pure b
hind, without any loss. A solid amalgam of lea
and another of bismuth being rubbed togethe
become fluid.

Mercury is the base of a new fulminating pow
der; which, however, is too delicate and dan
gerous a subject for you to meddle with. Th
powder is formed of mercury and the nitric acid

James. What is the mercurial preparation call
ed *turbith mineral?*

Tutor. It is a mercurial salt obtained by dissolving mercury in hot sulphuric acid. There are many other salts of mercury used in medicine and the arts.

Charles. Where does mercury come from ?

Tutor. It is imported to us chiefly from the East Indies. It is found in abundance in some parts of Spain, and in Germany. There is, in Peru, an immense quicksilver mine, 170 fathoms in circumference, and 480 in depth, in which are streets, and a chapel where religious services are performed on all festivals.

James. Where does the light come from ?

Tutor. The mine is perpetually illuminated by torches, flambeaux, &c. The inhabitants are all naked, or nearly so ; and thousands of human beings are annually destroyed by the unwholesomeness of the labour which they undergo in working the mine.

Charles. To what uses is mercury applied ?

Tutor. To many more than I can think of at present ; to silvering mirrors ; to the purposes of gilding, as we have seen ; for making barometers and thermometers, and in manufacturing vermillion ; also to various purposes in medicine. In South America it is used to separate the precious metals from the extraneous matter mixed with them.

Charles. How is that managed ?

Tutor. The mass is triturated with mercury ; the gold and silver become amalgamated with it. The amalgam is submitted to heat, which sublimes the mercury, and the perfect metals are left in a state of purity.

James. I think I have heard, that mercury is sometimes distilled ; pray how is that managed ?

Tutor. By putting the metal into a retort, and adapting to its beak a loose stopper of tow ; then adjust to the retort a matrass containing water. By applying a sufficient heat, the mercury passes over, and any foreign matters, that were mixed with it, will be left in the retort.

CONVERSATION XI.

Of Copper.

TUTOR. Here is a piece of copper, which is of a fine red colour, and very brilliant; its taste is nauseous, and, by meddling with it, the hands acquire a disagreeable smell. It is between eight and nine times heavier than water.

Charles. I am sure, that any person, who has ever been near a coppersmith's, will know that copper is malleable.

Tutor. It is also very ductile; and its strength, in the shape of wire, is so great, that one, not the tenth of an inch in diameter, will bear more than three hundred weight without breaking.

James. Does it easily melt?

Tutor. It can be melted by the application of a strong heat; and, if the heat be increased, it evaporates. After fusion, if allowed to cool slowly, it assumes a crystalline form.

Charles. As it is used for the sheathing of ships, I suppose the water has not much action upon it?

Tutor. Copper is not altered while kept under water, but by the action of the air the surface soon becomes oxydated.

James. Is that green crust, which we cal verdigris, an oxyde of copper ?

Tutor. It is found to be an oxyde of copper combined with carbonic acid gas. At the common temperature of the air the oxydation goe on but slowly ; but, if a plate of copper b heated red hot, it will be covered in a few minutes with an oxyde.

Charles. Then the oxyde may be obtaine readily in any quantity ?

Tutor. It may, by heating the copper, an plunging it alternately into cold water. Th scales fall down to the bottom of the water.

James. Is not the green colour formed o your hand, when walking with your coppe headed cane, an oxyde of copper ?

Tutor. Yes, it is : the heat of the hand, combined with the oxygen of the air, forms wit the metal the oxyde. It is the oxydation of th copper that renders vessels of this metal dangerous in the processes of cookery.

Charles. I think copper stewpans are use for preserving fruits and pickling vegetables o various kinds.

Tutor. The whole art in using copper vessels consists in keeping them very clean ; and to prevent mischief, nothing that is to be eaten *should be* suffered to cool in a copper vessel *neither fat,* nor oily substances, nor vegetabl acids, have any effect on copper while they are hot. If no liquid, therefore, be suffered to grow cold in copper vessels, they may be used with safety.(*a*)

Charles. Perhaps the green colour of the oxyde of copper might be the reason why the sulphate of iron, which is green, was called copperas?

Tutor. That is not an unreasonable conjecture.

James. How many oxydes of copper are there?

Tutor. Two: the protoxyde is of a fine orange colour; and the peroxyde is black, but in combination, it assumes various shades of blue, green, and brown. These are easily reduced to the metallic state, by heating them with charcoal, oil, and even with some metals, especially zinc.

Charles. Is copper combustible?

Tutor. When exposed to a stream of oxygen and hydrogen gas, the metal takes fire and burns with great brilliancy, emitting a lively green light of such intensity, that the eye can scarcely bear the glare. Copper leaves or wire, may be burned by the electric or Galvanic fluid.

James. Will copper unite with sulphur and phosphorus?

Tutor. It will: and thus are formed sulphurets and *phosphorets* of copper. The former *may be formed* readily by mixing copper filings and sulphur together, and making them into a paste with water. The phosphoret is formed by melting together sixteen parts of copper, sixteen parts of phosphoric glass, and one of charcoal.

Charles. Does copper combine with the other metals?

Tutor. It does with many of them, and the alloys so formed are of great importance. The alloy of gold and copper is that of which the gold coin in this country and France is formed, because the copper increases the hardness of gold without injuring the colour.

James. What are the proportions of the two metals?

Tutor. The greatest degree of hardness is obtained by a mixture of seven parts of gold to one of copper; but the current coin is alloyed with one part of copper to eleven of gold. The specific gravity of the compound is much above that of the mean. This alloy, being more fusible than gold, is employed as a solder to join pieces of that metal together.

Charles. Is copper, alloyed with the other metals, used for any practical purposes?

Tutor. An alloy of copper and platinum takes a fine polish, and is not liable to tarnish; and, on that account, it has been employed for the mirrors of reflecting telescopes.

James. Copper is, I believe, used in the *coinage of* silver, as well as of gold.

Tutor. It is: in the proportion of one part of copper to twelve of silver. The silver coin of France is purer than this, being formed of one part of copper to about nineteen of silver.

James. Do the acids combine with copper?

Tutor. Many of them do, and form with them salts that are used in the arts. The sulphate of copper, called Roman vitriol, is used by diers, and for varnishing guns, tea-urns, &c. The other salts of copper are used in pigments of different colours. Sulphate of copper is found in the streams of water that flow from copper mines; and, by keeping refuse iron, in bars or plates, in these waters, the sulphate is decomposed, and the iron soon acquires a covering of copper.

Experiment 1. When a mixture of three parts of metal, in the state of fine filings, with one of sulphur, is melted in a glass tube, at the moment of combination a brilliant inflammation ensues. Copper leaf burns in gaseous sulphur as brilliantly as iron wire in oxygen gas.

Ex. 2. Copper, combined with phosphorus, is said to acquire the hardness of steel: is susceptible of the finest polish, and is not altered in the air. Copper is much used in mixed metals, as brass, bell-metal, &c.

Charles. In what proportions are they used?

Tutor. Copper, with about a fourth of its weight of lead, forms *pot-metal*: with the same proportion of zinc, it composes *brass*, which is the most useful of all its alloys.

Mixtures of zinc and copper form the various compounds of *tombac*, *Dutch gold*, *Prince Rupert's metal*, *pinchbeck*, &c.

Copper and tin, with a little zinc, form *bronze*, *bell-metal*, or *gun-metal*. When tin is nearly one third of the alloy, it takes a beautiful polish, and is called *speculum metal*.

Ex. 3. A nitrate of copper may be thus prepared: let copper filings be dissolved in nitric acid, and when the effervescence subsides, boil the acid gently on the copper until a little skin appears; the solution is to be decanted and evaporated, until a strong pellicle is formed, when it is to stand to crystallize. The nitrate thus obtained is of a fine blue colour.

Charles. Where does copper come from?

Tutor. The island of Anglesea is very celebrated for its copper mines, which yield more than twenty thousand tons annually. In Cornwall also copper is found in abundance; and in other parts of the kingdom. Copper mines have been worked in China, Japan, Sumatra, and in the north of Africa.

James. Is copper found in combination with other metals?

Tutor. Yes, sometimes with gold, silver, and iron.

Charles. How are they separated?

Tutor. The ore is to be dissolved in the nitric acid, which will act upon and dissolve the *silver* and iron; the gold will be precipitated. *The silver* may be separated by immersing into the solution a polished plate of copper; the iron may be obtained by evaporating the solution to dryness; the residuum is a nitrate of iron and copper, which, being put in water, the oxyde of iron remains solid, while the water dissolves the nitrate of copper.

CONVERSATION XII.

Of Iron.

TUTOR. Iron, which is the subject of this morning's conversation, is the most useful and the most abundant of all the metals. Its outward appearance is too familiar to every person to stand in need of any description. Its specific gravity is between seven and eight times as great as that of water.

James. We all know that it is very malleable.

Tutor. It cannot, however, be hammered out into such thin plates as gold, silver, or copper; but it may be drawn out into a wire as fine as a human hair; and a wire, one tenth of an inch in diameter, will sustain, without breaking, nearly six hundred weight.

Charles. How many oxydes of iron are there?

Tutor. The *rust* of iron is an oxyde, which is produced by the gradual combination of the iron with the oxygen of the atmosphere, for which it has a strong affinity. It is admitted that there are two oxydes of iron, the protoxyde black, and the peroxyde red. The former is used in medicine, under the name of *martial ethiops*, and may be obtained, 1. From iron filings kept in warm water; 2. By making steam pass through a red-hot iron tube; the iron is changed into a brilliant, black, brittle substance, which, when pounded, has the appearance of martial ethiops; 3. By burning iron wire in oxygen gas.*

James. How is the peroxyde, or red oxyde obtained?

Tutor. By keeping iron filings red hot in an open vessel, and agitating them continually, till they are converted into a red powder.

Charles. With which of these oxydes is common iron rust to be classed?

Tutor. It is the red oxyde, combined with carbonic acid gas.

James. Will iron combine with sulphur?

Tutor. It will; and also with phosphorus and carbon, forming, with them, *sulphurets*, *phosphorets*, and *carburets* of iron.

Experiment 1. If equal quantities of iron filings and sulphur are formed with water into a paste, the sulphur decomposes the water, and absorbs the oxygen so rapidly, that the mixture sometimes takes fire, although it be buried under ground. Hence artificial earthquakes have been formed; and this fact is supposed to afford an explanation of the origin of volcanoes.

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* See vol. i, Conversations xii and xiii.

Ex. 2. The phosphoret of iron may be formed by dropping small bits of phosphorus into iron filings, heated red hot.

The carburet of iron is found native, known under the name of *plumbago* or *black-lead*, and is manufactured into pencils, crucibles, &c. A moderate heat has no effect upon it; but, when heated strongly in an open vessel, the whole burns slowly away, except about one tenth of a residuum, which is an oxyde of iron.

Charles. What is the distinction between *cast* iron, *wrought* iron, and *steel?*

Tutor. *Cast* iron is the name given to the metal when first extracted from the ores, which ores are composed of the oxyde of iron and clay.

James. How is the metal obtained?

Tutor. The ore is reduced to small pieces, and mingled with limestone and charcoal; and in this state it is subjected to a very violent heat. The carbon combines with the oxygen of the oxyde, and flies off in the form of carbonic acid gas, leaving the iron in a metallic state; the lime combines with the clay, and together form a sort of fluid glass. The melted iron, being heavier than the glass, falls down to the bottom of the furnace, whence it flows into moulds prepared for its reception. This is cast iron, which still contains carbon and oxygen.

James. How is it converted into wrought iron?

Tutor. By heat and by hammering:—by *these operations* it is deprived of the carbon and oxygen, which it retained in the cast state. If small pieces of iron are put into a crucible with a charcoal powder, and kept in a strong heat for several hours, they will then be converted into *steel.*

Charles. What are the peculiar properties of steel?

Tutor. It is brittle, resists the file, affords sparks with flint, and retains the magnetic virtue any length of time. It loses its properties by being ignited and cooled very slowly.

James. Is steel a compound of iron combined with charcoal?

Tutor. From what we have said before,* charcoal is an oxyde of carbon; but steel is proved to be iron combined with the carbon itself, and not with the charcoal; for steel has been formed by means of the diamond, which is pure carbon.

Charles. If I understand the subject, steel contains carbon, and so does cast iron, what then makes the difference between the two?

Tutor. *Steel* is composed of iron and a small portion of carbon; but cast iron is combined with a greater proportion of carbon than is necessary for the formation of steel; it is, perhaps, saturated with carbon. Cast iron is converted into wrought iron by burning away the carbon, and depriving it wholly of its oxygen.

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* *See vol.* i, Conversation xix.

James. Is there any method of distinguishing polished iron from polished steel?

Tutor. Yes, a very simple one: upon the two metals, as the blade of my penknife, which I know is excellent steel, and on the handle of the tongs, which is polished iron, I will put a drop of nitric acid, and let it remain five minutes, and then wash it off.

Charles. On the knife there is a dark brownish black spot left, but on the tongs the spot is of a whitish gray colour.

Tutor. The black spot on the steel is owing to the carbon which it contains, and which is converted into an oxyde, that is, into charcoal, by the acid. But upon the iron, which is nearly free from carbon, this effect cannot be expected, and the spot is barely visible to the eye.

James. Can iron be made to combine with other metals?

Tutor. Yes, it may, with most of them; it combines also with the acids, forming with them *salts*, that are very much employed in the arts and manufactures of this country; thus we have the sulphate of iron, called in the shops green vitriol, or copperas, used in dying, hat-making, ink-making, &c. The nitrates and muriates of iron are employed in calico printing.

Experiment. The effect of sympathetic ink may be obtained by writing with a pen dipped in very dilute solution of prussiate of potass.

Charles. I do not see any thing that you have written.

Tutor. I will moisten the paper with sulphate of iron, and now you see the writing is a fine blue.

James. Can the experiment be reversed?

Tutor. Yes: I will write with sulphate of iron, and moisten the paper with the prussiate of potass.

Experiment. If I write with an infusion of galls, the characters will not be legible till a solution of sulphate of iron is applied. This may be reversed.

Charles. From these substances ink is formed.

Tutor. True: and as ink is decomposed by most acids, which separate the oxyde of iron from the gallic acid, a solution of muriatic acid, and also some vegetable acids, will remove ink stains.

Ink is decomposed also by age, in consequence of the farther oxydation of iron, or of the escape of the acid of galls. Hence ink stains degenerate into iron moulds.

James. But iron moulds are produced almost as soon as the linen that has been stained with ink is washed.

Tutor. Because the alkali of the soap abstracts the gallic acid, and leaves only the oxyde of iron.

Charles. Iron is, I believe, found in many parts of this country.

Tutor. It is, and in great plenty in all the northern *parts* of the world. It is, as I have *already said,* the most useful and most abundant of metals. The practical knowledge of iron, and of the various uses to which it may be applied, may be said almost to distinguish the civilized from the savage world.

CONVERSATION XIII.

Of Tin and Lead.

TUTOR. This piece of metal is tin, usually called block tin.

James. I thought it had been tin, of which saucepans and other vessels used in the kitchen had been made?

Tutor. The substance of which these are manufactured is iron-plate, with a thin covering of tin only. Tin itself is white and brilliant, like silver, and is something more than seven times heavier than water; it is very malleable, and may be beat out into leaves, called tin-foil, not more than a thousandth part of an inch thick.

Charles. Is it easily melted?

Tutor. Yes, with a heat about double the temperature of that of boiling water: a much greater heat is necessary to cause it to evaporate.

James. Does it imbibe the oxygen from the atmosphere?

Tutor. When exposed to the air, it loses its lustre, and assumes a grayish white colour; but, when melted in an open vessel, its surface very soon becomes covered with a gray powder, which is the oxyde of tin. If the heat be continued, the powder becomes yellow; of course there are two oxydes of tin, the gray, or white, and yellow.

James. Are the oxydes applied to any use?

Tutor. The oxyde of tin, mixed with pure glass, forms a white enamel; it is also used as putty, in polishing steel and glass.

Charles. Will tin combine with other metals?

Tutor. Yes, with several. You know with mercury it makes an amalgam, which is used not only for the purposes of electricity, but for silver-mirrors.

James. How is it made to stick on glass?

Tutor. The tin-foil is laid on a flat polished stone, or slab of marble, and on it is spread the mercury; on this the glass is laid, and heavy weights placed on the glass. The mercury unites with the tin and adheres to the glass without any other preparation.

James. Is much mercury used in silvering a looking glass?

Tutor. Two ounces are sufficient for covering three square feet of glass

Equal parts of tin, lead, and bismuth, and two *parts* of mercury, make an amalgam for covering *curvilinear* glass mirrors. Hollow globes are *silvered* with an amalgam consisting of four parts of tin, and one only of mercury. Tin unites in various proportions with copper.

Charles. To what purposes are the alloys so combined applied?

Tutor. To the manufacture of cannon, bells, various articles made of bronze, and the mirrors of telescopes.

James. Are not the insides of copper vessels lined with tin?

Tutor. Yes: and the operation prevents the copper from oxydating, and thus preserves the food which is prepared in them from being injured by the copper. The vessels thus lined are said to be tinned.

Charles. Can you describe the manner in which this is done?

Tutor. The inner surface is scraped very clean, and then rubbed over with muriate of ammonia; (sal-ammoniac;) the vessel is heated, and spread over with pitch, and while the copper is still hot the tin is rubbed over, which gives it a silvery brightness.

James. How is the tin plate, which you said is iron tinned over, made?

Tutor. By dipping the plates of iron, thoroughly cleaned with sand, into melted tin, and then steeping them in water acidulated with sulphuric acid. In this way the tin penetrates the iron. The consumption of tin in this business is very considerable.

Charles. Are not common pins made of brass *tinned over to* make them white?

Tutor. Yes: the process is this; a vessel is filled by strata, or layers, with plates of tin, and brass pins, a tin plate being uppermost, and another at the bottom. It is then filled with water, and some tartaric acid, (cream of tartar,) by means of which the tin is dissolved; and after five or six hours' boiling, the pins are found uniformly tinned.

James. Does the brass precipitate the tin from the solution?

Tutor. Brass is a compound of copper and zinc; it is the zinc that has the affinity for tin, and, in this case, forms with it the union.

Charles. Is tin combustible?

Tutor. It is: in the shape of leaf it will burn in oxygen gas before it acquires a heat sufficient to fuse it. It is soluble in all the mineral acids: of course we have the sulphates, muriates, nitrates of tin, &c.

Experiment 1. You shall see, that the nitric acid is decomposed by the oxyde of tin, and red fumes are thrown off with rapidity. Now these have ceased, I will add a solution of potass.

Charles. It gives out a strong smell of ammonia.

Tutor. The tin decomposes both the acid and the water: the azote of the former combines with the hydrogen of the latter, and forms ammonia, which escapes in the shape of gas.

Ex. 2. Tin also decomposes the muriate of *ammonia.*

James. Is the muriate first dissolved in any fluid?

Tutor. No; equal parts of granulated tin and muriate of ammonia are put into a retort, which is to be adapted to a receiver in the mercurial apparatus. As soon as heat is applied to the retort, a decomposition takes place; the ammonia is disengaged in the form of gas; the muriatic acid combines with the tin, forming a solid muriate of tin, which may be decomposed with water.

James. Is tin applied to other uses besides those which you have described?

Tutor. The muriate of tin is very much employed in the processes of dying; it is the basis of the scarlet die: in glazing some kinds of earthenware tin is used, and in the manufacture of all kinds of pewter vessels, and plumbers' solder. The metal itself, as well as the white oxyde, readily combines with sulphur. The latter combination was formerly called *Mosaic gold*, which is used by japanners to give a beautiful colour to bronze, and to articles intended to have the appearance of gold.

Charles. Where is tin chiefly found?

Tutor. Much of the best tin is obtained from the mines in Cornwall and Devonshire; it is found also in different parts of Germany, and in the East Indies.

With LEAD, which is the next subject of our discussion, you are both well acquainted.

James. Yes, it is a very heavy metal, and softer, I think, than the other metals. Does it melt as easily as tin?

Tutor. Not quite as readily, but it may be made to boil and even evaporate. When exposed to the air it loses its lustre, and becomes white by its gradual combination with oxygen. If melted, and exposed to the action of the air, it becomes covered with a thin skin.

Charles. Is this an oxyde of lead; it is what I have been accustomed to call *dross?*

Tutor. It is: and, as we have mentioned before,* there are four different combinations of lead with oxygen.

James. What is white lead, which the painters use?

Tutor. It is a compound of an oxyde of lead and carbonic acid, formed by exposing thin plates of lead to the vapour of warm vinegar. Red lead, or minium, is the third oxyde of lead, formed principally by exposing, for a long time, the second oxyde, or massicot, to heat, during which it absorbs a larger quantity of oxygen.

Charles. To what have the oxydes been applied?

Tutor. They are all easily converted into glass, and in that state combine with the other metals, except gold, silver and platinum. This property renders them useful in separating gold and silver from the baser metals.

James. By what means is the operation performed?

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* See vol. i.

Tutor. The metal to be purified is melted with lead, which is gradually vitrified, and sinks in the vessel, carrying with it all the metals which were mixed with the gold and silver, and leaving these metals on the cupel in a state of purity. This process is called *cupellation.*

Charles. What do you mean by a *cupel ?*

Tutor. A vessel formed with a mixture of calcined bones and clay.—See the Index.

James. Is the lead of any use afterwards ?

Tutor. It may be extracted, and is known by the name of *litharge ;* but the best litharge is made by oxydizing lead, and increasing the heat till the oxyde is fused.

Charles. Does lead combine with the other metals ?

Tutor. It will with most of them ; the alloy of lead and copper is employed for the purpose of making printers' types, for very large characters. Lead and tin make pewter, plumbers' solder, &c.

James. Do the oxydes of lead readily give out their oxygen again ?

Tutor. Yes, by the application of heat ; and still more readily when distilled with sulphuric acid.

Charles. How is the process conducted ?

Tutor. Pour concentrated sulphuric acid on the red oxyde of lead, contained in a proper gas bottle, and let a gentle heat be applied ; the oxygen gas will come over, and may be preserved for use.

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The oxyde of lead decomposes muriate of soda.

Experiment. Mix two parts of finely powdered red lead with one of common salt, and form the whole into a paste with water; the alkali will be disengaged, and the acid will unite with the oxyde of lead. If the alkali is washed off, and the mass dried and fused in a crucible, it will form a pigment, called patent yellow.

James. Lead is a very useful metal; from it water-pipes and cisterns are made, and houses are covered with it.

Tutor. The salts of lead too, which are numerous, and the oxydes also, are employed in many of the arts of life, such as dying, calico printing, glass making, and in glazing earthenware, &c.

You have seen a *silver* tree; I will show you how to form an imitation of one in *lead.* In this bottle is a solution of acetite of lead in water, in the proportion of about forty parts of water to one of lead; I will suspend in it a little ball of zinc, and leave it undisturbed.—The zinc, as you will see, will soon be covered with a moss-like substance, which increases gradually, shooting out into a sort of leaves that range themselves into something of the shape of a tree.

Charles. How is this experiment explained?

Tutor. If you look into any table of affinities, you will see that zinc has a greater affinity for oxygen than lead; the zinc, therefore, takes the oxygen from the acetite of lead.

James. Does the lead return to its metallic state?

Tutor. It does: and by the laws of attraction unites itself to the zinc in the manner as you see.(*a*)

Charles. Where is lead found?

Tutor. It is generally found in the veins of rocks, combined with silver, antimony, sulphur, bismuth, &c. When combined with sulphur, the compound is then called *galena.*

James. Is not lead, when taken into the stomach, a poison?

Tutor. It is: and, when dissolved in acids, it imparts a saccharine taste to substances with which it is mixed; and on that account has, either through ignorance or roguery, been infused in stale wines, to render them pleasant to the taste, and vendible.

Charles. In this state is it called sugar of lead?

Tutor. Yes: but its proper name is acetate of lead, the metal being dissolved in acetic acid. This, and all the soluble salts of lead, are decomposed by sulphuretted hydrogen gas. A letter, therefore, written with a solution of acetate of lead, becomes legible on exposure to this gas.

CONVERSATION XIV.

Of Nickel, Zinc, and Bismuth.

TUTOR. Nickel is a fine white metal, resembling silver; and, like that metal, leaves a grayish trace, when rubbed upon the unpolished surface of plate glass. Here is a specimen.

James. I think it does not seem so heavy as lead.

Tutor. The specific gravity of nickel is about nine times greater than that of water. It is malleable while cold, but it cannot be heated without imbibing oxygen, which makes it brittle. It is not easily fused. It is now ascertained, that this metal is magnetic, and may itself be converted into a magnet.

Charles. What appearance has the oxyde of nickel?

Tutor. When heated in an open vessel, it combines with oxygen, and assumes a green colour; afterwards it acquires a tinge of purple, which gives to porcelain a beautiful and indestructible grass green.

James. With what substances will nickel combine?

Tutor. With sulphur and phosphorus: it is dissolved by the nitric and nitro-muriatic acid. The nitric solution has a grass green colour; and carbonate of potass throws down a green precipitate, which assumes a dark gray colour when heated. It combines with gold, copper, iron, tin, and lead.

Charles. For what purposes is nickel employed?

Tutor. It is not brought into use among us, but in China it is combined with copper, and applied to many uses. The difficulty of working it is the circumstance which has prevented nickel from being introduced to more general notice.

Zinc is another brilliant white coloured metal, composed of a number of thin plates adhering together; its specific gravity is about seven times as great as that of water. It is malleable; and it has been lately discovered, that it may be drawn into thin plates, and into wire, which was formerly doubted.

James. Is zinc easily melted?

Tutor. Yes, by a very moderate heat; and the fused mass, on cooling, forms regular crystals. When ignited, it is rapidly oxydized.

Charles. Is it acted upon by the air?

Tutor. Its lustre is soon tarnished, but it undergoes very little change from the action of the atmosphere. When kept under water, its surface soon becomes black; the water is decomposed, hydrogen gas is emitted, and the oxygen combines with the metal.

Zinc, kept melted in an open vessel, is soon covered with a pellicle, in consequence of its combination with oxygen. When this skin is removed, another soon succeeds; and in this manner the whole zinc may be converted into an oxyde.

James. Is zinc combustible?

Tutor. It is very combustible; when thrown into a crucible, and heated to whiteness, it suddenly inflames, and burns with a beautiful white flame. The oxyde sublimes in the form of carded wool; it has been called philosophical wool, and by others the flowers of zinc.

Charles. Is there only one oxyde of zinc?

Tutor. There are two, the white and the yellow. The solution of zinc in sulphuric acid shoots into regular crystals. This salt is soluble in water, and is not precipitated by any other metal.

James. Do sulphur and phosphorus combine with zinc?

Tutor. They do. *Blende* is found to be a sulphuret of zinc; the phosphoret may be formed by dropping small bits of phosphorus into zinc while in a state of fusion. Zinc combines, also, in the state of an oxyde, with sulphur and phosphorus, forming therewith sulphuretted and phos*phoretted* oxyde of zinc.

Charles. Will zinc combine with the other metals?

Tutor. It will with most of them; one part of zinc and three of copper form brass. When the alloy contains three parts of zinc and four of copper, it is pinchbeck. Tin and copper, with zinc, form bronze. Iron plates may be covered with zinc instead of tin.

James. How is zinc obtained?

Tutor. It is not found in Europe in a state of purity but is extracted from calamine, or lapis calaminaris, and other ores.

Charles. By what means?

Tutor. The calamine is pounded, and put in pots, with charcoal, into a furnace, and the heat drives off the zinc, which, by another operation, is reduced to the metallic state.

James. Does zinc, with the acids, form salts?

Tutor. It does with some of them: the acetate of zinc, formed of the flowers of zinc and acetic acid, is used in medicine externally, in cases of inflammation. The sulphate of zinc occurs in some mineral waters: this salt, known in commerce by the name of white vitriol, may be substituted for white lead in painting.

Experiment. Zinc will decompose nitric acid, as you shall see: I will put some granulated zinc in a Florence flask, and pour over it weak nitric acid; a strong effervescence will take place, and nitrous gas is disengaged.

Charles. Zinc, I believe, is the metal principally used in the experiments of Galvanism.

Tutor. It is: and with mercury and tin it makes one of the best amalgams for the purposes of electricity. The filings of zinc are mixed with gunpowder to produce the brilliant stars in artificial fireworks.

BISMUTH is of a reddish white colour, and is composed of plates adhering to each other: the specific gravity is almost ten times greater than that of water. It is in a small degree malleable, but it cannot be drawn into wire.

Charles. Can it be easily melted?

Tutor. It may, at a temperature of 460°; and, if the heat be much increased, it evaporates: after fusion, if allowed to cool slowly, it crystallizes in parallelopipeds, which cross each other at right angles. Bismuth inflames, when thrown into oxygenized muriatic acid.

James. Are there any oxydes of bismuth?

Tutor. There are two, the brown and the yellow[illegible] air takes away the lustre only, but [illegible] the first oxyde is obtained by keeping the metal melted in the open air, and the pellicles taken off as soon as formed. When it is raised to a strong red heat, it takes fire and burns with a faint blue flame, and emits a yellow smoke, which is a powder, and the second oxyde.

Charles. Are the oxydes applied to any uses?

Tutor. The second oxyde, when formed white by means of the nitric acid, is used as a pigment, under the name of pearl white; but its colour *is changed by* sulphuretted hydrogen. Both *oxydes are easily* converted into glass; and they may be reduced to the metallic state, when heated with charcoal and other combustible bodies.

Experiment. Mix together one part of the oxyde of bismuth and two of muriate of ammonia, and distil them in a glass retort, furnished with a receiver, containing a little water ; the ammonia will pass over and be absorbed by the water. What is left in the retort is the bismuth combined with muriatic acid, or a muriate of bismuth.

James. Does bismuth combine with sulphur ?

Tutor. It does : the sulphuret is of a grayish colour, and crystallizes into beautiful tetrahedral needles. The sulphur is less fusible than the metal itself. It combines with most of the metals. When eight parts of bismuth, five of lead, and three of tin, are melted together, an alloy is obtained, which melts in boiling water.

Charles. To what uses is bismuth applied ?

Tutor. It is used in the formation of printers' types, and to make pewter. Bismuth forms the basis of a sympathetic ink. The acetic acid must be employed for the solution of the metal. Characters written with this solution become visible when exposed to sulphuretted hydrogen.

oxyde. This being fused by a strong heat, runs into a glassy substance, and is called the glass of antimony.

Another combination of antimony is by boiling the native sulphuret, reduced to powder, with pure potass. The solution deposits, on cooling, a hydro-sulphuretted oxyde, called *Kermes Mineral*. A similar compound, but with a larger proportion of sulphur, was formerly called the *golden sulphur of antimony*.

James. Does antimony combine with the other metals?

Tutor. With most of them; but the greater number of alloys have not been applied to any practical purpose. Equal parts of antimony and copper, fused together, produce a most beautiful violet coloured alloy, formerly called *regulus of Venus*.

The alloy of tin and antimony is employed for making the plates on which music is engraved. Sixteen parts of lead and one of antimony form an alloy from which the greatest part of printers' types are made.

Charles. Is not antimony used very much in medicine?

Tutor. It combines with several of the acids, forming salts that are applied in various ways, and with the greatest efficacy in cases of extreme difficulty. Tartar emetic is composed of tartrate of antimony and tartrate of potass; and *James's powder* is a compound of which antimony is the principal ingredient.

Antimonial preparations are frequently given to horses, and other parts of the brute creation. Antimony may therefore be deemed a metal of very great importance.

James. Where is antimony found?

Tutor. It is obtained from an ore, which is abundant in some parts of Germany and in Norway. The ore on the large scale is purified by exposure to a strong heat in a *reverberatory furnace.* By this process the sulphuret is separated from the earthy matter: it is then devested of its sulphur by roasting, leaving the metal in the state of an oxyde.

James. What is a reverberatory furnace?

Tutor. Here is the representation of one. It is composed (see Fig. 13) of an ash-hole, *b*, destined to give circulation to a current of air, and to receive the ashes; a fire-place, *a*, separated from the ash-hole by a grate. C is the dome and chimney, which is moveable; it serves to reflect the flames on the retort D, the neck of which is inserted into the balloon E. On the top of the brick-work, near the corner, is a small hole, serving as a register.

Tellurium, in the metallic state, is of a bluish white, intermediate between that of zinc and lead; its texture is laminated like antimony, and its specific gravity is something more than six times greater than that of water.

Charles. Is it brittle, like antimony?

Tutor. It is, and capable of being reduced to *powder; but it* melts when raised to a temperature somewhat higher than the fusing point of lead; and, if the heat be then increased, it boils, evaporates, and attaches itself, in brilliant drops, to the upper part of the retort in which the experiment is made. When cooled it crystallizes.

James. Is it combustible?

Tutor. When exposed to the action of the blow-pipe upon the charcoal, it takes fire, and burns with a lively blue flame, and is completely volatilized in the form of white smoke. This smoke is an oxyde of tellurium, which may be obtained by dissolving the metal in nitro-muriatic acid.

James. Do you mean such a blow-pipe as that referred to before?

Tutor. That may be used; but I will show you a self-acting blow-pipe. E (Fig. 12) is a hollow sphere, which contains alcohol; it rests on the shoulder *g*; the tube G is continued within the sphere almost to the top, and serves for conveying alcohol, in the state of gas, to the flame at *o*.

Charles. Is that a small lamp?

Tutor. Yes: the heat of which causes the alcohol to boil, and to come over through the tube in the shape of gas; this being conveyed through the wick is inflamed, and produces a heat sufficiently strong to burn or melt any thing. At the top of the sphere is a safety valve, *x*, to prevent accidents, which might occur from a too sudden expansion of the fluid within. The lamp is moveable between two pillars, so that the flame may be brought nearer to, or carried farther from, the vessel containing the alcohol, as circumstances may require. The opening is that by which the alcohol is introduced into the sphere.

Charles. Does tellurium combine with sulphur?

Tutor. It does: and the sulphuret burns with a blue flame. It may be reduced to an amalgam with mercury.

James. Where is tellurium found?

Tutor. In the state of an ore in the mountains of Transylvania.

We proceed now to ARSENIC, which, though a most deadly poison, possesses many properties deserving of attention.

James. Is not arsenic a white powder?

Tutor. What is called arsenic in the shops is the *white oxyde of arsenic;* from this, however, the pure metal may be obtained. In the metallic state it is of a bluish white colour, not unlike steel: when heated it smells something like garlic. It is eight times heavier than water.

Charles. In this state is it easily oxydated?

Tutor. Yes: by the mere exposure to the atmosphere it is changed into a blackish oxyde. It is the most brittle of all metals, and is readily pulverized.

James. Does it easily melt?

Tutor. The melting point is not clearly ascertained, because it is so volatile that it sublimes without fusion, when exposed in close vessels to a heat of 540° of Fahrenheit.

Charles. How is the oxyde of arsenic obtained?

Tutor. The metal, when exposed to a moderate heat in contact with the air, sublimes in the form of a white powder; this is the white arsenic sold in the shops. It exists native, and is not often prepared by chemists. It possesses many properties of the acids. It combines with most of the metals, and renders them brittle.

Arsenic is capable of combining with another dose of oxygen, and forming a peroxyde, or, as it is generally called, the arsenic acid.

Charles. In what respect do these oxydes resemble acids?

Tutor. They redden vegetable blues: they combine with the pure alkalies to saturation, and the compounds have accordingly been denominated arsenites and arsenates; the first oxyde having been called arsen*ous* acid, and the second arsen*ic* acid.

James. Does sulphur combine with arsenic?

Tutor. They may be combined artificially, but the sulphuret of arsenic is found native in different parts of Europe, and in that state it has been called *realgar;* it is of a scarlet colour, and has been used as a paint. Arsenic combines also with phosphorus.

Charles. Does it enter into combination with the metals?

Tutor. It does with most of them, and renders them brittle and fusible.

The oxydes of arsenic, in solution, are discovered by sulphuretted hydrogen, which produce a yellow precipitate.

James. Is arsenic combustible ?

Tutor. In the metallic state, if it be inflamed, it will burn very brilliantly in oxygen gas.

Charles. Do the mineral acids act upon arsenic ?

Tutor. In a small degree only, unless they are heated. In oxygenized muriatic gas it burns with great rapidity.

Experiment 1. A mixture of oxymuriate of potass and arsenic forms a detonating compound, which takes fire with great rapidity. The salt and metallic oxyde may be mixed by stirring them together on paper with the point of a knife. If two trains be laid on a table, the one of gunpowder, and the other of this mixture, and then brought in contact with each other at one end, so that they may be fired at once, the arsenical mixture burns with the rapidity of lightning, while the other burns, in comparison, but slowly.(*a*)

Ex. 2. A small piece of metallic arsenic, placed between two plates of copper, and these bound together with iron wire, and heated to redness, the insides will be covered with a white colour.

Ex. 3. Tin, dissolved in arsenic acid, gives out an inflammable gas, consisting of hydrogen gas holding *some* arsenic in solution : if a stream *of this gas,* issuing from a bladder, fitted with a stop-cock, be set on fire in a large receiver filled with oxygen gas, it burns with a blue flame of uncommon splendour.

Arsenic destroys the magnetic virtue of iron, and of all other metals susceptible of that virtue.

James. To what purposes is arsenic employed?

Tutor. In its metallic state it enters into the composition of several alloys for the formation of specula: it is used in making small shot, to render the lead more capable of running into grains. It is employed, like many other metals, in dying and calico-printing: it enters into the composition of some sorts of glass, and it forms several excellent pigments. It is moreover used in medicine.

Charles. Is it not a dreadful poison; how then can it be given in medicine?

Tutor. In very small quantities it has been prescribed with the happiest effect in the most inveterate agues.

James. If arsenic should be taken in mistake by any person, is there any remedy against its deadly effects?

Tutor. The best thing that can be prescribed in such circumstances is the sulphuret of potass dissolved in water.

Charles. Where is arsenic found?

Tutor. In various parts of Germany, principally combined with the cobalt ores: it is sometimes found in iron and in copper ores.

CONVERSATION XVI.

Of Cobalt, Manganese, and Tungsten.

JAMES. Pray what is *cobalt*, to which you alluded yesterday ?

Tutor. It is a grayish coloured metal, sometimes composed of plates, sometimes of grains, and sometimes of very small fibres adhering to each other, obtained from a heavy mineral ore that has been used in many parts of Europe, almost for three centuries, to tinge glass of a blue colour.

Charles. What are the principal properties of this metal ?

Tutor. Its specific gravity is about eight times as great as that of water ; it is brittle, and may be fused, but it cannot be evaporated : it is attracted by the magnet, and may be converted into a magnet.

James. I think you said the cobalt ores contain arsenic.

Tutor. They do; and the separation of the two metals is, in Saxony, where the ores are principally found, performed only by persons who, for crimes, are condemned to death.

Charles. Is it a very dangerous business?

Tutor. So much so, that the poor wretches doomed to the employment seldom survive many years.

James. Is cobalt converted to an oxyde by being exposed to the air?

Tutor. It undergoes no change from the air, when cold, nor from water; but kept red hot in an open vessel, it imbibes oxygen, and is converted into a powder, at first blue, but afterwards it becomes almost black. If the heat be very great, the metal takes fire and burns with a red flame.

Charles. Is there only one oxyde of cobalt?

Tutor. Yes: it is capable of combining with three distinct doses of oxygen, and of forming three different oxydes. Cobalt, when oxydized, is the basis of *zaffre*, which, when fused, forms a blue glass; and this, when ground and washed, is the substance denominated *smalt*, used in painting and enamelling.

James. What acids have the most action on cobalt?

Tutor. The best solvents of this metal are the nitric and nitro-muriatic acids; from these solutions sympathetic inks are formed.

Charles. What are the proportions used in this case?

Tutor. One part of cobalt, or its oxyde zaffre, may be digested in a sand heat for some hours, with four parts of nitric acid. To the solution one part of muriate of soda is to be added, and four parts of water.

James. Are the characters to be written with this solution ?

Tutor. Yes : and they are perfectly illegible when cold ; but, when a gentle heat is applied, they assume a beautiful blue or green colour. Hold this paper to the fire.

Charles. There appears nothing on it : the trunk and branches of a tree begin now to show themselves : and now it is covered with a beautiful foliage.

Tutor. It requires only a little skill in drawing with this solution, and you may entertain your young friends in a thousand different ways.

James. What is meant by a sand heat ?

Tutor. A heat greater than can be given by boiling water. Vessels filled in part with dry sand, and heated by means of furnaces, are called *sand baths*, see Figs. 1—6.

James. Does cobalt combine with the other metals ?

Tutor. With most of them ; the alloys, however, are but little known, and are not much in use.

Charles. From what country does cobalt come ?

Tutor. It is very abundant in our own, in Somersetshire and in Cornwall. It is said by a t
veller, that the cobalt ores of Hesse, in Germany,

which at present produce 14,000*l.* per annum, were formerly reckoned of no other account than for repairing the roads.

We now come to MANGANESE, which is never found in a metallic state; but the metal is easily obtained by a chemical process from the oxyde.

James. Is the mineral then a metallic oxyde?

Tutor. It is; and the metal obtained from it is of a grayish-white colour, rather brilliant: its texture is granular, and its specific gravity is about seven times greater than that of water. It is neither malleable nor ductile.

Charles. Does the air act upon it?

Tutor. It attracts oxygen more rapidly than almost any other body. It loses its lustre immediately, and changes by degrees from gray to black. These changes take place more rapidly if the metal be heated in an open vessel.

James. How many oxydes of manganese are there?

Tutor. It is capable of combining with three different proportions of oxygen, and of forming three distinct oxydes, the white, the red, and the black. The two former are made artificially, the last exists abundantly in nature.

Charles. Is manganese generally found in this state?

Tutor. Yes: and to the black oxyde the appellation of manganese was originally applied.

James. I believe it is from this substance that oxygen gas is obtained.

Tutor. This oxyde is composed of three parts of manganese and two of oxygen; and, when heated to redness in an earthen retort, it gives out abundance of oxygen gas, which is readily collected.

Charles. Is this oxyde easily melted?

Tutor. It requires a very violent heat, and then it is converted into a green coloured glass.

A wind furnace (Fig. 15) is well adapted to purposes that require great heat. This figure represents the section of a wind furnace: A is the ash-hole, B the grate, C a crucible placed on the grate; F is a stone to cover the upper part of the fire-place, and D is the chimney; the longer the chimney the greater is the current of air.

James. By what means is the air conveyed to the fire?

Tutor. By a long tube, through which the air is conveyed from a distant cool place, either horizontally, or perpendicularly, underneath the furnace.

James. Is the metal soluble in the acids?

Tutor. Yes: but most readily in the nitrous acid. It is precipitated by alkalies, in the form of white powder. It combines with the other metals, and is scarcely ever found but mixed more or less with iron.

Experiment. When powdered manganese and nitre are mixed together, and thrown into a *red hot* crucible, the nitric acid is decomposed, and a compound of highly oxydized manganese with potass is obtained.

Charles. Are there any peculiar properties attaching to this compound?

Tutor. It exhibits different colours, according to the quantity of water that is added to it. A small quantity gives a green solution; a little more changes it to blue; some more gives a purple. The experiment may be varied by putting equal quantities of this substance into two glass vessels, and pouring on the one hot, and on the other cold water; the same material, with water of different temperatures, assumes various shades of colour, and on that account it has been called the *chameleon* mineral.

James. Where is manganese found?

Tutor. In the state of an oxyde in the Mendip hills, in Somersetshire, and in some parts of Devonshire. It abounds likewise in America, and on some parts of the European continent.

Charles. To what useful purposes has it been applied?

Tutor. Besides giving out abundance of oxygen gas to the chemists, it is used in bleaching, and in the manufacture of glass.

TUNGSTEN is another metal, obtained from a mineral found in Sweden: in its metallic state, it is something like iron, and is rather brilliant. It is one of the hardest of all metals; its specific gravity is more than seventeen times greater than that of water.

James. It is the heaviest of all metals then, except gold and platinum.

Tutor. It is; and it requires a very high temperature to fuse it. It is not acted upon by the magnet.

Charles. Does it absorb oxygen from the air?

Tutor. When heated in an open vessel it attracts the oxygen, and is converted into an oxyde.

James. Does it combine with one proportion of oxygen only?

Tutor. It is capable of uniting with two different proportions, and forming with them the black and yellow oxydes. The first, or black oxyde, is obtained by heating the yellow for some hours in a covered crucible. The peroxyde, or yellow oxyde, known also by the name of tungstic acid, is found native in wolfram, and may be obtained from it by boiling three parts of muriatic acid on one part of wolfram. The acid is decanted and allowed to settle. A yellow powder gradually precipitates, which is to be dissolved in ammonia; the solution is to be evaporated to dryness, and the mass kept for some time in a red heat. It is then yellow oxyde.

Charles. What are the properties of the tungstic acid?

Tutor. It agrees with other acids in combining with the alkalies and earths, and forming with them salts, called tungstates.

CONVERSATION XVII.

Of Molybdenum, Uranium, Titanium, Chromium, Columbium, and Tantalium.

TUTOR. We shall this morning easily finish our account of the metals. MOLYBDENUM is a metal of a whitish yellow colour; its specific gravity is between seven and eight times greater than that of water. At present it has been obtained only in very minute grains, and these are nearly infusible.

James. What is the nature of the mineral from which it is obtained?

Tutor. It is composed of scaly particles adhering slightly to each other. It has a strong resemblance to lead; from this mineral were obtained sulphur, and a whitish powder, which possessed acid properties. The powder at length proved to be a metallic oxyde, from which molybdenum was extracted in small particles.

Charles. The metal is, in this instance, procured from the oxyde; can the operation be reversed, and the oxyde be obtained from the metal?

Tutor. If it be exposed to heat in an open vessel, it gradually combines with oxygen, and is converted into a white oxyde, which is volatilized in small brilliant needle form crystals. This oxyde resembles the powder from which the metal was obtained, and is known by the name of molybdic acid, which is more than three times heavier than water.

James. Can the acid be dissolved in water?

Tutor. Yes, in a large quantity of boiling water, which will redden litmus paper. While in solution, it is easily precipitated by the sulphuric, nitric, and muriatic acids. When heated in a close vessel it melts and crystallizes; but, in an open vessel, it sublimes in white smoke, which attaches itself to cold bodies, and assumes the form of brilliant yellow scales.

Charles. Does it, like other acids, combine with the alkalies and earths?

Tutor. Yes; and also with several metallic oxydes; the salts thus formed are called molybdates.

James. Does the oxygen combine with the metal in a single proportion only?

Tutor. Molybdenum is capable of combining with four different proportions of oxygen, and of forming four oxydes, *viz.* the black, blue, green, *and yellow* or white.

Charles. As sulphur was found combined with molybdenum in the mineral state, it may be imagined the metal will also unite with it.

Tutor. It will; and also with phosphorus, forming with them sulphurets and phosphorets. It may be combined with some metals, but the alloys have not been examined.

James. Do the mineral acids act upon this metal?

Tutor. The nitric, nitro-muriatic, and oxymuriatic acids do: the others act upon its oxydes, and afford blue solutions.

The molybdic acid combines with the alkalies and the earths: it precipitates the nitrates of silver, mercury, and lead; the muriate of lead: and nitrate and muriate of barytes.

Experiment. A small rod of zinc, or pure tin, is acted upon by a solution of the acid, which becomes blue in consequence of the loss of a portion of its oxygen.

URANIUM is the next metallic substance to be noticed.

Charles. By its name I should suppose this was one of the substances that came from the clouds.

Tutor. The name was given it after the new planet discovered by Dr. Herschel, which some German astronomers would wish to denominate Uranus (Ουρανος.) The metal is obtained from a mineral found in Saxony, which was at first *called pechblende.*

James. Is it an ore of zinc ?

Tutor. You might well imagine this ; but its texture and specific gravity prove that it is not a *blende.* It is found to consist of sulphur, combined with a peculiar metal which is called uranium. It is of a dark gray colour, somewhat inclined to brown, obtained in grains, forming a porous mass. It is between six and seven times heavier than water, and requires a stronger heat to fuse it than manganese.

Charles. Can it be converted into an oxyde ?

Tutor. By means of nitric acid it may be converted into a yellow powder, which is the *yellow oxyde of uranium.* The mineral, from which the metal is obtained, is a native sulphuret of uranium, and the metal itself may be made to combine with sulphur.

TITANIUM is a metal obtained from a mineral found in Hungary, called *redshorl* or *titanite:* the same substance is obtained in Cornwall, where it is denominated *menachanite.* Little is known respecting this substance.

James. What are the properties by which it is distinguished ?

Tutor. Its colour is an orange-red, having a good deal of lustre : it is one of the most infusible metals, requiring more heat to melt it than can well be obtained : it tarnishes by exposure to the atmosphere, and is oxydized when heated with an access of air. It is capable of forming three different oxydes, the *blue*, the *red*, and the *white.*

CHROMIUM is a metal obtained from a mineral, known by the name of *read-lead-ore of Siberia*, which is found to be a combination of the oxyde of lead and an acid with a metallic basis.(*a*)

Charles. It is from this acid that chromium is obtained?

Tutor. It is; and, when obtained, the metal is very brittle, infusible, and fixed.

James. Will it combine with oxygen?

Tutor. Yes, in different proportions; and with them it forms three oxydes, *viz.* the green, the brown, and the yellow.

Charles. Do the acids act upon it?

Tutor. The nitric acid converts the metal into chromic acid, which combines with the alkalies. The alkaline chromates precipitate the salts of lead of a beautiful yellow colour. Mercury is thrown down of a cinnabar red colour; silver of a carmine red; and all its metallic combinations are distinguished by a peculiar brilliancy of colour. The *emerald* derives its colour from the *oxyde* of chrome, and the ruby from the *acid.*

COLUMBIUM is a metal discovered in a mineral, belonging to the British Museum, supposed to have been brought from Massachusetts, in North America.

James. Of what is the mineral found to consist?

Tutor. It is composed of one part of oxyde of iron, and about three parts of a white coloured substance, which possesses the properties of an *acid,* composed of oxygen united to a metallic *base.*

Charles. Has the acid been converted to a metallic state?

Tutor. Hitherto it has resisted all attempts for this purpose. It combines with the sulphuric and muriatic acids: it unites also with the alkalies.

TANTALIUM is a new metal, discovered as a component part of two minerals found in Finland.

James. What are the minerals called?

Tutor. The first is named *tantalite,* nearly eight times as heavy as water; the second is named *yttrotantalite,* about five times as heavy as water.

Charles. Was a metal extracted from each of these?

Tutor. From each of these was extracted a white powder, proved to be an oxyde of a metal: and from the oxyde was obtained the metal itself, which has the metallic lustre externally, but within it is black and destitute of brilliancy.

CERIUM is another new metal, which takes its name from the planet Ceres, which was discovered about the same time.

James. Where was this discovered?

Tutor. In Sweden, in a mineral, which is supposed to be an ore of tungsten, and named cerite.

Charles. Was it obtained in large quantities?

Tutor. No: in a small globule only, which was harder, whiter, and more brittle than pure cast iron.

CONVERSATION XVIII.

Of Salts.

CHARLES. I imagine, from what we heard in these chemical lectures, that there are a great many salts, though I had formerly thought the term was confined to the salt with which our food is seasoned.

Tutor. Originally the term was confined to that substance, which has been known and in use from the remotest antiquity; this substance, you know, is now denominated *muriate of soda.*

James. What, then, are we to reckon under the rank of salts?

Tutor. We may, speaking mineralogically, comprehend under them all the combinations of acids and alkalies, which exist in the mineral kingdom; (*a*) of these there are several species, under the genera POTASS, SODA, and AMMONIA.

Charles. What are the species of potass?

Tutor. There is but one, *viz.* nitrate of potass, or common salt-petre, which is found encrusting the surface of the earth in the East-Indies, and other warm countries.

James. Is nitre, or salt-petre, for I believe they mean the same thing, found on the surface of the earth?

Tutor. Not exactly in the state in which we find it in the shops; but it is produced naturally in great abundance, though mixed with many impurities. There is in Apulia a natural nitre bed, that furnishes the kingdom of Naples with great quantities of this substance; and in many parts of the continent salt-petre is extracted from the earth under the stalls of cattle, and from artificial nitre beds, formed for the purpose. You know of what it is composed?

Charles. It being a nitrate of potass, it must consist of nitric acid and potass; but I do not know where these can come from in stables, and such like places.

Tutor. The acid is a compound of oxygen and azote; the azote is disengaged from the putrefaction of animal substances, and combines with the oxygen of the atmosphere, forming therewith nitric acid; the potass is probably furnished by the vegetable substances and the soil.

James. How many species of salts are there of the soda?

Tutor. There are four, *viz.* the carbonate, the sulphate, and the muriate of soda; and also borax, called borate of soda.

Charles. Where is the carbonate of soda found?

Tutor. In Egypt, on the surface of the earth, and on the margin of certain lakes, which become dry in the summer. It is also found in various parts of Asia. It is composed, as you know, of carbonic acid and soda.

James. Where is the sulphate of soda found in a native state, which is, I know, a compound of sulphuric acid and soda?

Tutor. In many parts of Germany, Switzerland, and Siberia; it is found usually in a state of powder, but sometimes in masses, and sometimes crystallized.

Charles. The muriate of soda, or common salt, is found, I know, in England.

Tutor. It is, and in many other countries, particularly in Poland. Near Cordova, in Spain, there is said to be a mountain of common salt, 500 feet high, and three miles in circumference.

James. Is borax a compound of soda also?

Tutor. It is soda combined with the boracic acid, and is found in Thibet and in Persia, in large crystals, enclosed in a fatty kind of matter.

Charles. What species of salts are there in ammonia?

Tutor. Only the muriate of ammonia, which is obtained near volcanoes, and also in Persia. It is usually found in the state of powder, in the middle of lava; but sometimes in mass, and sometimes in irregular crystals.

Such are the salts found in a natural state in, or on the surface of the earth.

James. You have often referred to salts formed with the different earths, and metallic oxydes.

Tutor. I have; for chemists now agree, pretty generally, to comprise under the general name of salts, all the compounds formed by the combination of acids with alkalies, earths, and metallic oxydes; and they are named, as you now know, from the acid; thus, we have the sulphate of potass, of lime, of iron, &c. &c. The second part of the compound, *viz.* the alkali, the earth, or the oxyde, is called the base of the acid. Thus, of nitre, or the nitrate of potass, potass is the base; and of common salt, or muriate of soda, the soda is the base.

James. The number of salts must be regulated according to the number of acids, and the number of bases.

Tutor. There are thirty-two acids and fifty-seven bases; accordingly, these numbers, multiplied together, give 1824, which would be the number of salts, if every base would combine with each acid; but this is not the case; some cannot combine with several of the acids. On the other hand, some of the acids are capable of combining with two bases at once. After all, the number of salts is not completely ascertained.

Charles. What is meant by the phrase *neutral salt?*

Tutor. Formerly it was used to denote the combination of any acid with an alkali, earth, or metallic oxyde; but now the term neutral is ap

TABLE

OF THE

GENERA, SPECIES, NAMES, AND COMPOUNDS OF SALTS.

Genera.	*Particular Species.*	*Common Names.*	*Of what Compounded.*
Muriates	Muriate of Soda	Common Salt	Muriatic acid and Soda.
Fluates	Fluate of Lime	Fluor Spar	Fluoric acid and Lime.
Borates	Borate of Soda	Borax	Boracic acid and Soda.
Sulphates	Sulphate of Soda	Glauber's Salt	Sulphuric acid and Soda.
Phosphates	Phosphate of Lime	Animal Bones	Phosphoric acid and Lime.
Carbonates	Carbonate of Lime	Chalk, Marble, &c.	Carbonic acid and Lime.
Nitrates	Nitrate of Potass	Nitre, or Salt-petre	Nitric acid and Potass.

Charles. In looking over the table, it strikes me, that the common names are much more simple than the others, which seem complex, and difficult to be remembered; *salt*, for instance, is more simple than *muriate of soda;* and *chalk*, or *marble*, than *carbonate of lime.*

Tutor. We are accustomed to the old names, which is the only advantage belonging to them; whereas the new ones show the nature and composition of the substance spoken of. To take your own instances, what idea does the word *chalk* give, in comparison of the term *carbonate of lime*, which shows, in an instant, that it is a compound substance of carbonic acid and lime. Take another example or two; you are reading a book, and meet with the word *gypsum*, which the author explains farther on by the phrase *plaster of Paris.*

Charles. Neither of them conveys to my mind any definite idea, because I have never seen gypsum.

Tutor. The new chemical term for it is *sulphate of lime.*

Charles. Then we instantly know it is a substance compounded of sulphuric acid and lime.

Tutor. What idea would the word *copperas*, one of the ingredients of ink, give you?

James. The idea of a metallic substance, of which copper is at least a part.

Tutor. It would, and thus mislead you, for it *is a substance* composed of sulphuric acid and *iron, and is* properly called a sulphate of iron.

CONVERSATION XIX.

Of the Muriates and Oxymuriates.

TUTOR. I shall, in this and a succeeding Conversation or two, give you a short description of some of the more important salts, leaving you to investigate the others for yourselves hereafter. To begin with the muriates, which are distinguished by the following properties. 1. When heated, they melt, and are volatilized. 2. They are soluble in water. 3. They effervesce with sulphuric acid, and white acrid fumes are disengaged. 4. When mixed with nitric acids they exhale the odour of oxymuriatic acids.

Charles. I know common salt, which is the muriate of soda, will, if thrown on a plate of hot iron, melt and evaporate, and that it is very soluble in water.

Tutor. In each of these glasses I have put *half a tea*-spoonful of common salt; to one will add some sulphuric acid, and to the other I will pour a few drops of nitric acid.

James. They both effervesce and throw off powerful fumes, but the odour is evidently different in each. Would there be the same results if any other of the muriates were used instead of salt?

Tutor. Yes, the properties above mentioned are common to them all.

Charles. How many muriates are there?

Tutor. There are twelve of the alkaline and earthy muriates; these are the muriates of barytes, potass, soda, strontian, lime, ammonia, magnesia, magnesia-and-ammonia, glucina, yttria, alumina, and zirconia.

James. Is not one of these, *viz.* the muriate of magnesia-and-ammonia, a triple salt?

Tutor. It is: for the muriate of magnesia combines with the muriate of ammonia, thereby forming a salt different from either. The most important of the muriates are those of soda and ammonia.

Charles. Salt is not made from muriatic acid and soda.

Tutor. Great plenty of it is found already formed, so as to preclude the necessity of making any artificially. Immense quantities are dug out of the ground, which require only to be cleared of their impurities and reduced to powder. In this state it is called rock-salt. The water of the ocean also contains a large proportion of this salt which is obtained by evaporation. Nevertheless, by saturating muriatic acid with soda, the solution w the flavour of culinary salt.

James. Perhaps the muriatic acid is from the salt ?

Tutor. It is: and so is soda, which merly got wholly from the combustion tables.

Charles. By what processes are t tained ?

Tutor. The acid is extracted by m the sulphuric acid, which has a greater for the soda than the muriatic acid, course it combines with the soda, w acid escapes. The soda can be had b of litharge, lime, or iron.

Experiment 1. Four parts of litha one of salt, pounded, mixed, and mace a small quantity of water for several ho frequently stirred; the muriatic acid g combines with the oxyde of lead, and muriate of lead, while the soda is left tion, and may be obtained by filtering a poration.

Ex. 2. A mixture of lime and comm formed into a paste, and placed in a m lar, will, in a few days, be covered efflorescence of soda.

Ex. 3. An iron plate, dipped in a so salt, and suspended in a cellar, will, i ays, be encrusted with soda.

James. Common salt is of great use, I believe, in many respects besides that of seasoning our food?

Tutor. Yes: it serves for enamels to stoneware; it is used in dying and in assaying some metals; and, if the heavy taxes upon it did not prevent, it would be much employed in agriculture. The whole animal creation are fond of it; and cows are said to give more, and equally good milk, when moderately fed with salt. It is also used in the manufacture of soap.

The other salt, which we shall notice among the muriates, is the muriate of ammonia, or sal-ammoniac.

Charles. From whence did it derive its name?

Tutor. From the circumstance of its being obtained in great quantities near the Temple of Jupiter Ammon, in Africa.

James. Is it dug out of the ground?

Tutor. No: the dung of cattle is burnt, and from the soot the muriate of ammonia is extracted, which is sent over in hard elastic cakes.

Charles. Can it be formed artificially?

Tutor. If equal measures of ammonical gas and muriatic gas be mixed together, over mercury, they are immediately condensed; a white cloud is formed, and a solid substance is deposited on the sides of the vessel. This is real muriate of ammonia.

James. Is it soluble in water.

Tutor. Yes, in about three times its weight of water, at the temperature of 60°, and, during the solution, much caloric is absorbed.

Charles. I recollect it is used among the freezing mixtures.

Tutor. By the addition of pure potass or soda, either in the dry state or in solution, the ammonia is disengaged, as is evident by the pungent smell that arises on the mixture of those substances.

James. For what is the muriate of ammonia used ?

Tutor. It is used by diers, and also by coppersmiths, who employ it to prevent the oxydation of the metal which they cover with tin.

Besides the muriates, there are salts, which are denominated *hyperoxygenized muriates* ; these are formed with acid, that is in the highest degree oxygenized.

Charles. What are the properties of these salts ?

Tutor. When mixed with any combustible body, as sulphur, or charcoal, they detonate with great violence, by mere friction. I will mention two or three experiments, which must never be attempted but by experienced chemists.

Experiment 1. By rubbing together three grains of this salt,(*a*) and one of sulphur, in a mortar, with a metallic pestle, a series of small explosions take place.

Ex. 2. If the same mixture be struck on an *anvil,* it will give a report as loud as that of a gun.

Ex. 3. Three parts of the salt, with one of sulphur and charcoal, mixed, produce the most terrible explosions.

Ex. 4. If the same mixture be thrown into concentrated sulphuric acid, a flame is given out so powerful as to be almost too strong for the human eye to bear.

James. Are these what are called the fulminating powders?

Tutor. This is one of them, and, perhaps, the most terrible of them all.(*a*)

CONVERSATION XX.

Of Sulphates and Phosphates.

TUTOR. SULPHATES are the next genus of salts to be considered. 1. They have a bitter taste. 2. They may be dissolved in water, but not in alcohol. Alcohol, indeed, precipitates them from water in a crystallized state. 3. When heated to redness, with charcoal, they are converted into sulphurets.

Experiment. I have put a tea-spoonful of sulphate of magnesia (Epsom salt) into some water. It is completely dissolved, and the solution is quite clear. I will now add some alcohol to it, and you will see the salt is precipitated.

Charles. Is this salt prepared artificially ?

Tutor. Scarcely ever : it exists abundantly in sea-water, and in the uncrystallized residuum in salt-pans, after all the common salt has crystallized.

James. I have often taken Epsom salts ; they *make a sad* bitter dose.

Tutor. Yes: this salt is often used as a purgative; but its great use is in furnishing magnesia. Almost all the magnesia of commerce is extracted from it.

Charles. How is it obtained?

Tutor. It is dissolved in water, and precipitated by alkalies.

James. How many sulphates are there?

Tutor. There are fifteen; of these, five are triple salts, and some varieties; thus, there is the sulphate of potass and supersulphate of potass.

Charles. What methods are adopted in preparing these two salts?

Tutor. The sulphate of potass is formed by saturating dilute potass with sulphuric acid, and then evaporating the solution till crystals appear. The supersulphate is obtained by heating together a mixture of three parts of sulphate of potass and one of sulphuric acid.

James. Is it by this means that the sulphate gains its excess of acid, on account of which it takes the prefix *super?*

Tutor. It is; and this excess may be dissipated again by heat, and then it is converted into a sulphate.

Sulphate of lime is known also as gypsum; it is found in great plenty in many places, particularly near Paris, the hills about which are almost entirely composed of it; hence its other name, plaster of Paris. When ground and burnt, it is miscible with water, which it absorbs very rapidly, and becomes solid almost immediately; on this account it is employed in forming casts, bust cornices, &c. When this salt was formed arti cially, it was formerly called *selenite.*

Among the sulphates is reckoned alum, which there are four varieties, all triple salt being sulphates and supersulphates of alumi and potass, and alumina and ammonia.

Charles. Is alum much used ?

Tutor. It is employed as a mordant in dyin also in the manufacture of leather ; it is al used by calico-printers and engravers, and f preserving animal substances from putrefactio It is a principal ingredient in *pyrophorus.*

James. What do you mean by pyrophorus ?

Tutor. If three parts of alum and one of flou or sugar, be melted together in an iron ladle, a the mixture dried till it becomes black and cea es to swell ; and if it then be pounded small, p into a glass phial, and placed in a sand bath till blue flame issues from the mouth of the bottl and, after burning a minute or two, be allowed cool, a substance is obtained called *pyrophor* which has the property of catching fire whene er it is exposed to the open air.

Charles. Is there any thing remarkable in t phosphates ?

Tutor. 1. Before the blow-pipe they are co verted into a globule of glass. 2. They are s luble in nitric acid with effervescence, and pr cipitated from the solution by lime-water.

James. Do phosphates combine with an exce *acid ?*

Tutor. They do: and form superphosphates. The most interesting of these salts is the phosphate of lime, which constitutes the basis of bones.

Charles. How is it obtained from these?

Tutor. Calcine the bones to whiteness; reduce them to powder, and wash them with water to separate the soluble salts. Dissolve the whole in muriatic acid, and precipitate it by means of ammonia. The precipitate is pure phosphate of lime.

James. Is it ever found native?

Tutor. There are mountains of it in Spain; it is in regular crystals; and, in that state, it is known by the name of *apatite*. Phosphate of lime is found in other animal matters besides the bones. It exists also in the farina of wheat, in such quantities, that it has been calculated a person, who eats a pound of wheat per day, will, in a year, take nearly three pounds and a half of phosphate of lime.

The phosphate of soda is employed as a purgative; the purposes of which it answers, unaccompanied by the nauseous taste which ever attends the Epsom and Glauber's salts.

CONVERSATION XXI.

Of the Carbonates, Nitrates, and Metallic Salts.

TUTOR. We come now to the carbonates, which are, 1. Soluble in water. 2. When sulphuric acid is poured upon them, they effervesce violently, emitting carbonic acid gas.

Charles. Are these salts found native ?

Tutor. Many of them are ; but they may all be formed artificially, by dissolving the base in water, and making carbonic acid gas pass into the liquid till it be saturated.

James. How many of these salts are there ?

Tutor. There are reckoned eleven, several of which are capable of combining with an excess of acid. Of the carbonates the most important is the carbonate of lime, which exists in nature under the names of marble, chalk, and limestone ; but of this we have conversed amply before.

Charles. How are the nitrates characterized?

Tutor. 1. They are soluble in water, and capable of crystallizing by cooling. 2. When heated to redness with combustible bodies, a violent detonation is produced. 3. Sulphuric acid disengages fumes from them. 4. When heated with muriatic acid, oxymuriatic acid is exhaled. There are twelve nitrates.

James. Is not nitre one of them?

Tutor. Yes: it is a compound of nitric acid and potass, and is therefore the nitrate of potass. This salt, of which we have spoken before, detonates with combustible bodies more violently than any other of the nitrates.

Experiment 1. When nitrate of potass, mixed with one third part of its weight of charcoal, is thrown into a red hot crucible, or when charcoal is thrown into red hot nitre, a detonation takes place, and likewise one of the most brilliant combustions that can be exhibited.(*a*)

Ex. 2. A mixture of nitre and phosphorus, being struck smartly with a hot hammer, will give a violent detonation.

Charles. Is not this salt a principal ingredient in gunpowder?

Tutor. The best proportions for gunpowder are:—

Nitrate of potass,	76 parts.
Charcoal, ...	15
Sulphur, ...	9
	100

James. How is gunpowder formed ?

Tutor. The ingredients just mentioned are first reduced to fine powder separately ; then mixed intimately, and formed into a black paste, with water. After this has dried a little, it is placed on a kind of sieve, full of small holes, through which it is forced. It is thus divided into grains.

Charles. How is it glazed ?

Tutor. The powder, when dry, is put into barrels that turn round on their axes ; by means of this motion, the grains of gunpowder rub against each other ; their surfaces are made smooth, and the powder is said to be glazed.

James. Is there not a fulminating powder obtained from nitre ?

Tutor. Yes : three parts of nitre, two parts of potass, and one of sulphur, all previously well dried and mixed together in a warm mortar, form a compound of that kind.

Experiment. If a small quantity of this powder be put into an iron spoon, and placed upon burning coals, or held over the flame of a candle, it blackens, and then melts ; and, at the instant of melting, it explodes most violently, and a strong impression is made upon the bottom of the spoon, as if it had been beat inwards.

Charles. Is this salt used for any thing else ?

Tutor. From nitrate of potass the nitric acid is obtained ; it is also a principal ingredient in the black and white fluxes.

James. What are fluxes, and what are their uses ?

Tutor. A flux is a fusible substance, which is mixed with metallic ores, or other bodies, to assist in their fusion. *Black* flux is formed by setting fire to a mixture of one part of nitrate of potass, and two parts of tartrite of potass; and *white* flux is obtained by throwing into a red hot crucible equal parts of the same salts.

This account of the principal alkaline and earthy salts will be sufficient for our purpose. I shall now proceed to some few particulars respecting the metallic salts.

Charles. How many metallic bases are there, from which these salts derive their characteristic properties?

Tutor. There are twenty-three bases, and thirty-one acids, with which each base may be combined.

James. Do the metals combine with acids?

Tutor. No; it is the oxydes, or certain compounds, which they form with oxygen; the metals themselves seem to be incapable of combining with any acid.

Charles. Some metals form two or more oxydes; in that case, will there be two or more metallic salts formed, by combining with the same acid?

Tutor. Certainly: take iron as an instance. Of this metal there are two oxydes, the black and the red; and there being thirty-one acids, we must reckon upon sixty-two salts of iron, provided it be found that each of the oxydes is capable of combining with all the acids. Do you know in what the difference between the oxydes of the same metal consists?

James. In the proportion of oxygen which they contain.

Tutor. Right: and oxydes, which do not contain a maximum of oxygen, have a tendency to absorb it, whenever it is presented to them, till they are completely saturated. This tendency is shown most when the oxydes are combined with acids, and in a state of solution; of course those metallic salts, the bases of which do not contain a maximum of oxygen, are liable to absorb that principle, and by that means to be converted into a different salt.

Charles. Can you give us an instance?

Tutor. Green vitriol, which is a sulphate of iron, composed of sulphuric acid and black oxyde of iron, when dissolved in water and exposed to the air, soon absorbs more oxygen, and the black oxyde is converted into red: thus a new salt is formed, composed of sulphuric acid and red oxyde of iron.

James. Is not this something similar to what takes place in the earthy and alkaline salts, that contain an acid, with a minimum of oxygen, as the nitrites, sulphites, &c.?

Tutor. In both cases, indeed, oxygen is absorbed, and a new species of salt formed; but, with regard to the earthy and alkaline salts, the oxygen combines with the acid; while, in the *metallic salts,* it combines with the base.

CONVERSATION XXII.

Of the Metallic Salts.

CHARLES. How do you distinguish between the metallic salts, as those formed, for instance, from the black and red oxydes of iron?

Tutor. It is recommended by Dr. Thomson to denominate the one, simply, sulphate of iron, and the other, which has absorbed a larger portion of oxygen, either the *oxysulphate*, or the oxygenized sulphate of iron. As an example of the metallic salts, we shall consider the salts of mercury.

James. What are their distinguishing characteristics?

Tutor. 1. When they are strongly heated, they are volatilized and dissipated. 2. Hydrosulphuret of potass occasions a black precipitate. 3. Muriatic acid, when poured into a solution of them in water, usually occasions a white precipitate. 4. Gallic acid occasions a yellow precipitate. 5. A plate of copper, plunged into a mercurial salt, gradually precipitates running mercury.

Charles. How many mercurial oxydes are there?

Tutor. There are four; but, with regard to their combining with acids in forming salts, Dr. Thomson notices but two.

James. Will every acid combine with each of these oxydes?

Tutor. It should seem so, from every thing that is known of them; therefore every species is divisible into two varieties, which are distinguished by the simple name, and by prefixing to it the epithet oxygenized.

Charles. Are any of these capable of existing in more states than one?

Tutor. Yes, in both states; in one in which there is an excess of acid, and also in the other, where there is an excess of base. These salts are characterized by the prepositions *super* and *sub*. Hence, another set of varieties arises; an example of each may be enumerated under the sulphates of mercury; thus, we have

1. Sulphate. 2. Oxysulphate.
3. Supersulphate. 4. Superoxysulphate.
5. Subsulphate. 6. Suboxysulphate.

James. Have all these varieties something interesting to recommend them to the attention?

Tutor. To you they cannot be very interesting; nor would it be of avail even to enumerate *all the genera*, much less so the species of the *metallic* salts. I have selected only the salts of mercury, as a specimen, to show you how chemists treat the subject, in order that, when you come to study books, you may find no obstacles that may embarrass your mind, or impede your progress. Of the salts of mercury I shall notice but two species, with the varieties, *viz*. the nitrates and muriates.

Charles. Has the nitric acid any action on mercury ?

Tutor. It has, and forms with it the nitrate and oxynitrate.

James. Does the oxynitrate contain mercury oxydized to a maximum ?

Tutor. It does. Besides these, there is a *super*nitrate, consisting of the first of these salts, combined with an excess of acid ; and a *sub*nitrate, consisting of the nitrate combined with an excess of base.

Charles. How does the nitric acid act on mercury ?

Tutor. When it is poured upon mercury an effervescence takes place, and nitrous gas is disengaged ; the metal is gradually oxydized, and afterwards dissolved in the acid that remains undecomposed, which, being evaporated, yields the nitrate of mercury.

James. What are the properties of the nitrate of mercury.

Tutor. When it is placed upon burning coals it detonates feebly, emitting a lively flame. When mixed with phosphorus, and struck with a hot

3. the cortical layers, which form a kind of net work.

Charles. Do these unite in forming a solid covering to the *wood*, which is the main substance of the plant?

Tutor. They do; and the *pith* is situated in the centre of it, and is a spongy substance, containing a great number of cells.

James. I can see a resemblance between the structure of vegetables and animals, the *bark* answers to the *skin*, the *wood* to the *muscular flesh*, and the *pith* to the *spinal marrow*.

Tutor. There is, however, this important difference between them; vegetables are fixed to the spot, while animals are, in general, possessed of the powers of motion, which they are obliged to exercise, in order to procure food for their sustenance.

James. It must then depend on the situation in which the seed is placed, whether the future plant shall become vigorous or not; it has no means of seeking for a more congenial soil.

Tutor. On that account millions of the vegetable tribe spring up, sicken, and die, without coming to perfection.

Charles. Almost any soil will, I believe, be sufficient for the first stages of vegetation.

Tutor. The first food of the plant is contained in the seed, as that of the bird is in the egg. The egg requires but a proper degree of temperature, whether afforded by the parent hen, or by artificial means, to produce the animal; so th seed of a plant, being put in favourable circumstances, changes to a substance of a saccharine nature, which serves, at first, for food to the vegetable; it is then said to germinate. The food, however, contained in the egg in one case, and in the seed in the other, is soon exhausted; and, as the bird can seek its proper food from surrounding places, so the plant must derive its future nourishment from the air and soil in which it is placed. If these are unfavourable to vegetable life, the plant will droop and die.

James. Is the structure of vegetable seeds the same in different kinds?

Tutor. The seeds of vegetables, in general, consist of three parts, *viz.* the *radicle*, which is converted into a root, that pushes into the ground; the *cotyledons*, which, emerging above the ground, expand in the form of leaves, called *seminal* leaves; and the *plumula*, which becomes the stem to which leaves and branches are affixed.

Charles. As the vegetable tribe derive nourishment from the air and soil, of what does a vegetable consist?

Tutor. The constituent principles of vegetables are hydrogen, carbon, and oxygen.

James. Are these common to all vegetables?

Tutor. They are: other substances are found in particular plants, but they do not necessarily belong to the whole race. Of these elementary *principles*, hydrogen and oxygen have a strong *tendency* to unite with caloric, and to be converted into gas; while carbon is more fixed, having but a small affinity to caloric.

Charles. The formation of oxygen gas from vegetables, in the light of the sun, is, then, I think, easily explained.

Tutor. Water and air form the principal part of the food of vegetables, which possess the power of decomposing these substances. The hydrogen of the water is retained, the oxygen is first absorbed, but the greater part seems to be given out again by the leaves, which will, as you say, explain the mode by which oxygen gas is obtained from the leaves of plants.

Although the constituent principles of plants consist of these three simple substances; yet from plants themselves a number of important substances are derived, which may be analyzed by chemical means.

James. I am not surprised at this, when we have seen, that the combination of different proportions of azote and oxygen give, as results, the common atmospheric air, nitrous gas, and even nitric acid, that very corrosive substance.

Tutor. The principal substances which are met with in vegetables, are *mucilage* or *gum*, *fecula*, *jelly*, *sugar*, *gluten*, *oil*, *camphor*, *wax*, *resin*, *extract*, *caoutchouc*, *acids*, *tannin*, *colouring matter*, *suber* and *wood*.

Charles. By what means are vegetable substances analyzed?

Tutor. Various methods are adopted, and various agents are employed for the purpose, such as heat, the acids, water, alcohol, and the processes of fermentation.

James. I know what *gum* is, for I have frequently taken it from cherry and plumb trees: is *mucilage* another name for the same thing?

Tutor. Various parts of vegetables impart to water in which they are boiled a certain viscous substance, this is called mucilage, and has all the properties of the gum, which is frequently found exuding from some trees spontaneously.

Charles. Gum is easily dissolved in water: it has no taste, I think, and is brittle when dry and cold. What makes the difference in the colour of gum, some of which is yellow, and some is of a fine clear white?

Tutor. The action of the light destroys the yellowness of the gum, which is the only effect produced upon it by exposure to the atmosphere. It is insoluble in alcohol and oil.

Experiment. Here is a solution of gum water, I will add to it some alcohol.

James. It is decomposed.

Tutor. Yes: water has a stronger affinity for the spirit than it has for the gum; it therefore seizes on the alcohol, and precipitates the gum.

Charles. Of what is gum composed?

Tutor. It is a compound consisting of oxygen, hydrogen, nitrogen, carbon, and lime.

James. From what trees is *gum arabic* obtained?

Tutor. From a species of the *acacia*, that grows *Arabia* and Egypt: it is said to possess very nutritive qualities, and that a thousand persons, travelling in the caravans to Cairo, in the year 1750, subsisted entirely on gum for two months, who must otherwise have been starved, having, by stress of weather, been detained in the desert so much longer than was expected.

CONVERSATION XXIV.

Of Fecula, Jelly, Sugar, Gluten, Oil, Camph
Wax, Resin, Extract, Caoutchouc, Bitumens.

CHARLES. What is meant by the word *fecu* which is the next article in your list?

Tutor. It constitutes the chief part of nutritive grains; it is likewise called fari Starch may be taken as an example: it is soluble in water at the usual temperatur when the water is heated to 160° it will dissol starch, and at 180° the solution coagulates.

James. Is it in this state that it is used stiffen linen?

Tutor. Yes, it is; because, by increasing t temperature of the water, the starch is eas made into a thickish kind of paste.

Charles. How is it obtained from the origi substance in which it exists?

Tutor. It is extracted from barley, whi contains it in abundance, and also from whe rye, potatoes, &c., by beating or kneading flour of the several substances with a large quantity of water. The water takes up the starch, and, when suffered to stand quiet, it subsides without trouble ; the water is then decanted, and the starch left till it becomes sour ; it is then washed repeatedly and dried. It is this part of grain that is convertible into sugar ; and on this property the process of malt-making consists.

James. I have often wondered why malt is so sweet, since in barley there is no taste of sugar.

Tutor. It must, however, exist in the barley, and in the farina of it. Malt is made by steeping the barley in water for two or three days ; it is then spread on a floor, where it begins to germinate ; and, when the radicle is from one half to three quarters of an inch long, it is several times turned, in order to stop the progress of vegetation ; and then it is finally placed in a kiln to be completely dried.

Charles. Of what does farina consist ?

Tutor. It has been analyzed, and found to be compounded of carbon, hydrogen, and oxygen.

James. Is *jelly*, the next substance, that which is obtained from ripe fruits, such as currants ?

Tutor. Yes : it is soluble in hot water, and the solution again gelatinizes on cooling. It combines with alkalies.

With *sugar* you are well acquainted.

Charles. That is the produce of the sugar cane, cultivated in the West Indies. Sugar is *very soluble* in water.

Tutor. It is obtained in great abundance from the sugar cane: but it is also diffused in almost all vegetables. Alcohol dissolves about one fourth of its weight of sugar. Sugar has the property of rendering oils miscible with water. Alkalies destroy its taste, which may be recovered by adding sulphuric acid, and precipitating the sulphate by means of alcohol, which retains the sugar in solution.

James. What are the component parts of sugar?

Tutor. Oxygen, carbon, and hydrogen, in the proportions of 64, 28, and 8.

Charles. How is sugar obtained from the cane?

Tutor. The juice is pressed out, and boiled with lime-water to a proper consistence; it is then drawn off into another vessel, where it is allowed to concrete, and the liquid and impure part, called the molasses, to separate from it. Sugar thus obtained is in small hard grains, and is brought into this country under the name of *raw sugar.*

James. How is the loaf sugar made?

Tutor. The raw sugar is dissolved in water, mixed with lime, clarified by means of bullock's blood, and then boiled down to a proper consistency: it is now poured into unglazed conical earthen vessels, where it is allowed to grain. There are, however, still impurities mixed with it.

Charles. How are these disposed of?

Tutor. The point of the cone is undermost, and perforated, and on its base is a covering of moist clay, the water from which gradually filters through the sugar, carrying away with it the impurities.

James. What is *refined* sugar?

Tutor. It is loaf sugar redissolved, and treated in the same way a second time.

Charles. What is *gluten?*

Tutor. It is an elastic substance, resembling an animal matter, found in many vegetables, but chiefly in wheaten flour. It is insoluble in water; but alcohol will dissolve a small quantity of it, and the solution may be applied to the purposes of varnish.

James. Of what does it consist?

Tutor. It differs from the vegetable substances by containing a larger proportion of nitrogen, and some ammonia. Gluten, when kept moist, ferments, and undergoes a sort of putrefaction, emitting an offensive odour.

Oil, the next substance to be attended to, is obtained from vegetables by pressure, chiefly from the seeds and kernels of plants, as the olive, the almond, linseed, &c.

Charles. This will not combine with water.

Tutor. Nor with alcohol; but, as we have seen, oil unites with the alkalies and forms soap.

James. What is the *drying* oil of the painters?

Tutor. Some oils, as that of linseed, dry of themselves; but this property is very much in-the lower extremity, while, at the same time, no gas can return through the funnel.

Charles. In what respect do the fixed oils differ from the essential oils?

Tutor. The latter are obtained by distilling aromatic plants with water. The water rises, accompanied with the oil, which for the most part floats on the surface. It is very inflammable, and flies off in vapour at the heat of boiling water. Oil of lavender, rosemary, &c. are oils of this kind.

Experiment. If nitric acid, mixed with one sixth part of sulphuric acid, be poured upon any of the essential oils, the mixture bursts out into a violent flame. This experiment should be done with the greatest precaution, as the inflamed oil is scattered about in all directions.

James. Will the essential oils unite with alkalies, and form soap?

Tutor. Not without great difficulty: several of them will detonate, when rubbed with hyperoxygenized muriate of potass, and take fire when poured into oxygenized muriatic gas.

Here is a vessel (Fig. 17) for separating ethereal oils from water. The bent neck, x, being lower than the mouth, acts like a syphon when the vessel is nearly full to the brim, and the oils, being lighter, swim on the water. Hence, by hydrostatical principles, the latter, entering into the lower part of the spout, flows off, while the oil remains. If the oil is heavier than water, *which is* sometimes the case, another funnel is sunk in, through which the oil passes to the bottom, and the water runs off by a similar side aperture, as that in the figure, but nearer the brim of the vessel.

Camphor resembles the essential oils in many properties; it is soluble in alcohol and the oils.

Charles. Does it inflame with the nitric acid?

Tutor. No: it is dissolved by it; but the camphor soon separates, and floats upon its surface.

James. From what is camphor obtained?

Tutor. From a species of laurel growing in China, Japan, and Sumatra. All the parts of the camphor tree are impregnated with the oil, but the roots contain the most. It is extracted by chopping the wood of the tree very small, and laying it in water, and distilling it. The camphor thus obtained is afterwards purified by sublimation. It consists of carbon and hydrogen.

Charles. Is not *wax* formed by the bees?

Tutor. It is collected by them from the antheræ of flowers. It is likewise found upon the upper surface of the leaves and fruits of many trees.

James. This is very fusible and inflammable I believe.

Tutor. Certainly: it is insoluble in water, bu in boiling alcohol it may be dissolved in considera ble quantities: it is soluble also in volatile an fixed oils.

Charles. What is meant by *resins?*

Tutor. They are the juices of certain plan *which exude* spontaneously from some pla and from others they are obtained by wounding the bark: turpentine and guaiacum are resins. They are usually yellow, and imperfectly transparent.

James. Do they dissolve in water?

Tutor. No; but they are soluble in alcohol, ether, and the essential oils; from these solvents water will precipitate them.

Charles. Of what are resins composed?

Tutor. They are generally regarded as volatile oils, combined with oxygen. They are extremely valuable for varnishes, and are used in medicine.

There are also *gum-resins*, which are mixtures of resin and mucilage. They are soluble, partly in water, and partly in alcohol. They are much employed in medicine. Assafoetida, gum-ammonia, myrrh, opium, gamboge, are varieties of gum-resin.

James. What is meant by the next vegetable substance, denominated *extract?*

Tutor. It exists abundantly in the juice of all plants, and may be obtained by evaporating an infusion of them, prepared by boiling, in distilled water. Thus, we have extracts of saffron, of bark, of senna, &c.

Charles. Is this soluble in water?

Tutor. Yes, in cold water, but more copiously in hot. If exposed to the air it gradually absorbs oxygen, and then loses its solubility in water. It is a compound of carbon, hydrogen, nitrogen, and oxygen. Liquorice juice is an extract.

You know what *caoutchouc* or elastic gum is.

James. We are acquainted with its uses, but not at all with its origin : I should hardly have supposed that it was a vegetable substance.

Tutor. It is the juice of a tree found in South America of the euphorbia tribe. It is first thick, and of a milky nature, and becomes concrete on being exposed to the air.

Charles. Is it not always black ?

Tutor. It acquires this colour from the mode of drying it. Did you ever burn a piece of this substance ?

James. No : but I will try it now ;—it burns with a bright flame.

Tutor. Of course it is inflammable, and in oxygen gas it exhibits a remarkably brilliant light. From its great elasticity it is called *gum elastic*, and, from its property of rubbing out black-lead pencil lines, it is called indian rubber.

Charles. Is it easily dissolved ?

Tutor. Not in water, nor in alcohol ; but it is soluble in essential oils, and in ether prepared for the purpose. If long slips of this substance are tied spirally round glass or metal rods, and boiled for an hour or two, the edges cohere, and a tube is formed. Tubes of this kind have been used in surgical cases.

James. What are the component parts of *caoutchouc ?*

Tutor. From various experiments, it is supposed to consist of carbon, hydrogen, azote, and oxygen. This substance has been obtained from the misletoe, gum-mastich, and various other plants.

Charles. What are *bitumens?*

Tutor. Though bitumens, on account of their origin, are with propriety classed among mineral substances, yet in their chemical properties, they are more closely allied to the products of the vegetable kingdom. Like vegetable substances in general, they burn in the open air, and with a degree of brightness that surpasses even that of resins. By distillation, they yield a weak acetic acid, an empyreumatic oil, some ammonia, and a considerable quantity of carburetted hydrogen gas. Bitumens have been divided into liquid and solid.

James. What are the names of the bitumens?

Tutor. The chief of the bituminous substances are naphtha, petroleum, mineral tar, mineral pitch, asphaltum, pit-coal, bituminous wood, turf, and peat.

Charles. Do you mean by *naphtha,* the fluid in which the newly discovered metals, potassium and sodium, are best kept?

Tutor. I do: it is a light, thin, colourless oil, and highly odoriferous, which is found on the surface of the water of certain springs in Italy, and on the shores of the Caspian Sea. Its specific gravity is about .7 or .8, water being 1; that *is,* about one quarter lighter than water.

James. Is not naphtha very inflammable?

Tutor. It is, and burns with a penetrating smell, and much smoke. By long exposure to the air it becomes thick and coloured, and passes to the state of petroleum.

Naphtha is the only fluid with which we are acquainted, in which oxygen does not exist in considerable proportion.

Charles. Is that the circumstance which renders it of use in preserving the new metals?

Tutor. It is: because they have so great an affinity for oxygen, that they seize upon it whenever they come in contact with it, decomposing in an instant the atmospheric air, water, &c., seizing on the oxygen, and setting at liberty the other gases.

James. What is *petroleum?*

Tutor. It is thicker than naphtha; has a greasy feel; is wholly or in part transparent, and a little heavier than naphtha.

Charles. Is this inflammable?

Tutor. It is very highly so; and it has the property of combining with fat and essential oils; with resins, camphor, and sulphur; and, when rectified, it dissolves caoutchouc.

Mineral tar is thicker and more viscid than petroleum, and of a reddish or blackish brow colour. In its chemical properties it resembl petroleum.

James. What do you mean by *mineral pitch*

Tutor. This also is extremely inflammabl of a brown or blackish colour, and of a speci gravity equal to between one and a half and twice greater than that of water.

Charles. Is *asphaltum* of the same nature as the other bitumens which you have just described?

Tutor. It is, with regard to its inflammability. It is not so heavy as mineral pitch, and is soluble in naphtha. The solution is of a deep black colour, and forms an excellent varnish.

James. Is *pit-coal* the substance which we burn?

Tutor. Pit-coal is a general term applied to several distinct varieties of minerals. They are often divided, for the sake of description, into three families, *viz.* brown coal, black coal, and glance coal.

Charles. The coal we burn must be the black coal.

Tutor. Brown coal is only imperfectly bituminized, and exhibits distinctly the remains of the vegetables, from the decay of which it has unquestionably originated. It is light enough to float on water; burns with a clear flame, and with a bituminous smell mixed with that of sulphur. It has often the resemblance to wood that has been half charred.

James. Is the black coal that which is perfectly bituminized?

Tutor. It is: in this there are no traces of the remains of the vegetables from which it originated. It is thought to be a compound of bitumen and charcoal; and, according to the different proportions of these two ingredients, its properties vary. The best kinds melt on the application of a moderate heat, and burn almost entirely away, with few ashes as a residuum.

Charles. I have often observed coals to burn away, almost like pitch.

Tutor. These may be distilled; and, as results, they give out tar; heavy carburetted hydrogen gas, now used in gas-lights; and in the retort is left a hard, heavy kind of charcoal called coak.

James. What is *glance* coal?

Tutor. It appears to consist of almost pure charcoal, without any bitumen, and combined only with a portion of earth. In many parts it is called *stone* coal.

Charles. Does this admit of distillation?

Tutor. It does, but it yields no tar; but a carburetted hydrogen gas, which, from its inferior density, cannot be used as gas for lamps.

James. Is *peat* of the same nature as coal?

Tutor. Peat, or turf, is the remains of vegetable organization, and consists, in a great measure, of fibres of several mosses, with occasionally whole branches, and even trunks of various trees. It is extremely inflammable in the open air, and, when distilled in close vessels, yields products similar to those of coal.

CONVERSATION XXV.

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Of Tannin, Colouring Matter, Suber, and Wood.

TUTOR. Of the vegetable acids we have already treated; we proceed to *tannin*, or the *tanning principle*.

Charles. Is not that obtained from the bark of the oak?

Tutor. Yes, and from the gall-nut: and also from the bark of all *astringent* vegetables. Its chief property is that of forming an insoluble compound with animal jelly; on this property is founded the art of tanning hides, or making leather.

Charles. In what manner is this substance obtained?

Tutor. By adding to a strong infusion of oak-bark a solution of muriate of tin, a precipitate is thrown down containing tannin and oxyde of tin. *This is to be* dissolved in water, and sulphuretted hydrogen added, which unites with the tin, leaving the tannin free.

Charles. What is meant by the *colouring matter.*

Tutor. It is that part of vegetables that is used for dying, calico-printing, and other operations of a similar nature.

James. Is it found separately in them ?

Tutor. No : it is combined, 1. with the *extractive matter:* 2. with the *gum ;* in these cases it is soluble in water : 3. with the *farina ;* in this instance it is easiest soluble in sulphuric acid : and 4. with resins, when it requires alcohol, oil, or an alkali for solution.

Charles. Is the colouring matter easily obtained ?

Tutor. It has a great affinity for alumina and the oxyde of tin ; in consequence of which, the solutions of these substances readily precipitate infusions of the colouring matter in water.

The modes of obtaining, and of transferring the colouring principle from one body to another, so that it shall be irrevocably fixed, constitutes the whole art of dying.

James. I was not aware, that all the beautiful colours to be seen on cottons, silks, wools, &c., were obtained from vegetable substances.

Tutor. The great variety of colours, observed in died substances, are reducible to four simple ones ; *viz.* the *blue*, obtained from indigo ; the *red,* afforded by cochineal, madder, archil, *Brazil-wood,* and the saffron flower ; the yellow, obtained from wild American hiccory, sumach, turmeric, fustic, and quercitron bark; and the *black* is a combination of the red oxyde of iron with gallic acid and tan.

Charles. Are these colours fixed by merely dipping or boiling the substances in them?

Tutor. Some of the colours are permanently attached to the fabric in this way, while others would leave a mere stain, removable by washing.

James. How are those to be fixed?

Tutor. Through the medium of a proper *basis.* The principal bases are alumina, and some of the metallic oxydes, in combination with the several acids.

Charles. Then colours are distinguished into those that are permanent of themselves, and those that are not so?

Tutor. They are; the former are denominated *substantive* colours; the latter are called *adjective* colours.

I will now show you a few experiments, which will make this subject sufficiently intelligible, without going into the whole theory.

Experiment 1. In this glass is a solution of indigo, in diluted sulphuric acid; and I will add to it an equal quantity of carbonate of potass. I will dip into it this piece of white cloth.

James. It is a fine *blue.*

Tutor. *Yellow* cloth dipped in it will be changed to green, and *red* will be converted to a fine *purple.*

Cochineal is naturally of a red colour; but it is used for scarlet dying; to obtain the scarlet hue, a *tartrite of potass* is used as a base.

Charles. Is cochineal reckoned among the substantive or adjective colours?

Tutor. It is an adjective colour; the basis by which it is fixed to the cloth is the oxyde of tin.

Ex. 2. Here is a decoction of cochineal, which will only stain a piece of cloth; I will add to it some tartrite of potass and a little nitro-muriate of tin, and now it will afford a permanent scarlet colour.

Ex. 3. Here is some die from the quercitron bark, a species of oak; this is an adjective colour; but by the aid of alumina, as a base, we get, as you shall see, a bright yellow. With the oxyde of tin, all the shades from a pale lemon to a deep orange are formed; and with the oxyde of iron it gives a drab colour,

Ex. 4. To this solution of carbonate of potass, I will add an equal quantity, by weight, of nitrate of iron. This will produce the permanent buff colour of the calico printers.

Ex. 5 Equal quantities of arnotto and potass of commerce, dissolved in boiling water, will give the nankeen die.

Ex. 6. Here is a piece of dark brown linen, which has been died with fustic; I will, with a camel's hair brush, draw some figures on it, with a solution of muriate of tin. The figures will *quickly* appear yellow instead of brown.

Charles. Will you repeat to us the process of dying ?

Tutor. The stuff to be died must first be cleared of all glutinous and greasy matter, by being washed ; it is then, in some cases, to be bleached, by exposing it to the action of oxygen. The piece thus prepared is to be impregnated with the *mordant*, which is to fix the colour, such as *alumina*, the *muriate of tin*, &c., and then it is to be passed through the colouring liquid.

Charles. What do you mean by the term of mordant ?

Tutor. To make the colour stand, it is, in general, found necessary to use an intermediate substance between the colouring matter and the stuff to be died ; this substance is called the mordant.

James. Will not the colour last without this precaution ?

Tutor. In almost all cases the stuffs would lose their colour again by exposure to the air, or by washing in water. Mordants are employed to give lustre as well as durability.

James. I thought the alumina and metallic oxydes had been previously mixed, as bases to the colouring matter ?

Tutor. In some cases they are ; and, when used as mordants, they must be so contrived as to have an affinity both for the colouring matter and the stuff itself. By a decomposition between the mordant, and the substance which holds the colour in solution, the colour is precipitated on the base of the mordant, and adheres to it.

CONVERSATION XXVI.

Of Fermentation.—Putrefaction.

TUTOR. Having already given an account of those principles which constitute the vegetable, we shall now consider the changes to which they are subject.

James. Do you refer to putrefaction, to which all vegetables are liable when dead?

Tutor. That is one of the changes to which I mean to call your attention; but there are others, which come first in order; these may be ranked under the general term of fermentation, of which there are three kinds enumerated by Dr. Thomson, *viz.* the *panary*, the *vinous*, and the *acetous.*

Charles. What is meant by fermentation?

Tutor. It is a spontaneous motion, which takes place in certain substances when exposed to the air, and a proper degree of temperature.

James. In what does it differ from putrefaction?

Tutor. Putrefaction is the last stage of fermentation; they are both distinguished by the odour thrown off in the state of gas, or vapour, which, when very offensive and noxious, the spontaneous decomposition is called putrefaction: but when the smell is not offensive, or when any of the new compounds formed by the decomposition can be applied to useful purposes, the spontaneous decomposition is called fermentation.

Charles. I think I understand it now; by *fermentation* is meant the spontaneous changes which take place in vegetable substances, after they are separated from the living plant; putrefaction succeeds fermentation.

Tutor. Two things are absolutely necessary to fermentation: 1. A certain portion of moisture; and, 2. A temperature higher than the freezing point.

James. Have not some vegetable substances a greater tendency to fermentation than others?

Tutor. Certainly: sugar, gum, wax, resins, camphor, &c., placed in circumstances the most favourable for fermentation, show little disposition to change. Whereas gluten, some of the vegetable acids, and extract, are quickly decomposed. But fermentation is most perceptible, and the change is most remarkable, when several vegetable substances are mixed together. When gluten, for instance, is added to a solution of water, it turns to vinegar.

There are some substances peculiarly efficacious in exciting fermentation; these are called *ferments.*

Charles. Is yest one of these?

Tutor. It is: and is, as you know, used fo the purpose in the process of brewing, distilling and bread making.

James. Now I know what is meant by *panar* fermentation; it is that which takes place in making bread. Would not the flour and water ferment without yest?

Tutor. It would, but not quick enough to mak good bread; it would become sour. Paste thu made, and suffered to get sour, is called *leaven* a small quantity of this, added to newly mad paste of flour and water only, will quickly caus the whole to ferment, and to swell in every d rection; and from this, if the proportions ar well adapted, good bread may be made.

Charles. I now see the meaning and force the expression, "*a little leaven leaveneth the wh lump.*"

James. What is the cause of the swelling the paste?

Tutor. By fermentation, a gas, probably carbonic acid gas, is evolved; but, as the p is too stiff to let it escape, it causes it to s out in every direction; and, if baked in state, the air-bubbles, imprisoned in every render the bread full of little holes, called and very light.

Charles. I wonder why so much pains s be taken to get yest, and such complaints when, in hot weather, it is scarce, sinc *can be made* so easily without it.

Tutor. The thing is far from easy; and the difficulty of proportioning the old *sour* leaven to the new paste, which must be done with great nicety, has led to the general use of yest, or barm, as it is called in some countries.

We shall proceed to *vinous* fermentation; this comprehends every species of fermentation, which terminates in the formation of an intoxicating liquid.

James. Does it include all kind of spirits, as well as wine and beer?

Tutor. It does: but all these liquids may be divided under two general heads: 1. Those obtained from the juices of plants, as wines of all kinds; and, 2. Those obtained from the decoction of the seeds, as beer.

Charles. Will you explain the nature of vinous fermentation?

Tutor. From ripe fruits, as the grape, currant, apple, &c. may be expressed a liquid of a sweet taste, which is called *must*; this is found to be composed of water, sugar, jelly, gluten, and an acid partly saturated with potass. When the must is brought into a temperature of about 70°, the different ingredients act upon each other, and the vinous fermentation commences; the liquor becomes thick, the temperature increases, and carbonic acid gas is evolved. In a few days the fermentation ceases; the liquor becomes clear, it has lost its saccharine taste, and *one* of a pungent nature is acquired. In a short time after this, it acquires a brisk taste, and an intoxicating property.

James. To what is the strength of wine attributed ?

Tutor. Principally to the sugar, for it has been shown, by experiments, that always, in proportion to the quantity of sugar in the *must* is the strength of the wine.

Charles. Will sugar and water make wine ?

Tutor. The vinous fermentation will not take place unless yest be added : it seems to be an established principle, that, for the production of wine, five things are indispensably necessary : 1. a certain temperature ; 2. water ; 3. sugar ; 4. a vegetable acid ; and, 5. gluten.

James. How then is wine made with sugar, water, and yest only ?

Tutor. Because yest contains the gluten and the vegetable acid.

Charles. As the sweet taste is lost during fermentation, it should seem that the sugar is decomposed.

Tutor. Do you recollect of what sugar is formed ?

Charles. Of oxygen, carbon, and hydrogen.

Tutor. In fermentation, the oxygen and carbon of part of the sugar are supposed to combine, and go off in the shape of carbonic acid gas ; while the other part of the sugar, containing an excess of hydrogen, remains in the form of alcohol.

James. What is alcohol ?

Tutor. It is a highly inflammable spirit, composed of hydrogen, carbon, and oxygen. It is found in all wine, which is indebted to it for its strength.

Charles. What other principles does wine contain?

Tutor. 1. An acid: besides this, those that possess the property of frothing, when poured into a glass, contain carbonic acid gas. 2. The *extractive* matter, to which it is indebted for colour; this diminishes in proportion to the age of the wine, as it gradually precipitates to the bottom or sides of the vessel. The colouring matter of wine is separable by lime-water.

The principles now laid down will explain the nature of all intoxicating liquors, as cider, perry, and English made wines.

James. Does the process of brewing, or beer making, materially differ from that of the manufacture of wine?

Tutor. Beer is obtained from malt by means of vinous fermentation; and from beer, even small beer, alcohol may be obtained.

Charles. What is *acetous* fermentation?

Tutor. If wine, or beer, be exposed to a heat of from 75° to 85°, and air freely admitted, it loses its taste and smell, becomes sour, and turns to vinegar.

James. Is weak or strong wine most readily converted to vinegar?

Tutor. The weaker fluids are the best for the purpose, as strong wine, or strong beer, resists the change.

Charles. What is the cause of this change?

Tutor. The absorption of oxygen from the atmosphere; of course, if wine be preserved from all access of the air, it will not become sour.

The last change, or final decomposition of vegetables, is *putrefaction;* in this state ammonia is formed, accompanied by a very offensive smell; to accomplish which, moisture, heat, and a proper access of air, are necessary.

James. You have told us of what alcohol is composed: pray how is it obtained in that state of purity in which it is used in Chemistry?

Tutor. It is obtained by repeated distillations from wine, or even beer, or from spirit of wine, to which the very dry sub-carbonate of potass is to be added: the mixture is to be well shaken; the clear liquor is then to be decanted, and this operation is to be repeated as long as the alkali is moistened by the spirit. When the potass has absorbed all the moisture, the clear liquid is to be distilled by the heat of a water bath, and the result is pure alcohol.

Charles. Will not alcohol boil with a heat much lower than that required to bring water to the boiling point?

Tutor. Yes, it will: but it has a still more valuable property; it has never yet been congealed by any degree of artificial cold, which renders it of great importance as a thermometer for very low temperatures.

By distillation with certain acids, alcohol forms ether, which is the lightest and most volatile of all liquids.

James. How is ether obtained?

Tutor. There are different processes, according to the acid made use of. Nitric ether is thus prepared: to a quart of alcohol, contained in a glass retort, I must add, by degrees, half a pound of nitric acid; and, after each addition, the materials must be cooled, by setting the retort in a vessel of cold water. The mixture is then to be distilled, till about a pint and a half have come over.

Charles. Is that pure nitric ether?

Tutor. No, it must be redistilled, with the addition of pure potass; preserving only about the first half, or three fourths, of that which comes over. This is pure ether.

James. What are the properties of ether?

Tutor. Some of the most striking are as follow: It is extremely evaporable; a few drops poured on the hand, produce a sense of cold. By pouring a small stream of ether on the bulb of a thermometer filled with water, from a capillary tube, the water is frozen. A mixture of the sulphuric and muriatic ethers, produces a degree of cold below 0 of Fahrenheit. It dissolves resins and essential oils, and resins. It is highly inflammable, and when mixed with oxygen gas it detonates loudly.

Experiment. Into this strong two ounce phial, filled with oxygen gas, which I have wra round with cloth, to prevent accidents, I wi fall a drop of ether, and then apply the fla a candle to the mouth of the bottle.

Charles. It has produced a very violen port.

CONVERSATION XXVII.

Of Animal Substances.

TUTOR. Animal substances, concerning which we are to converse to-day, are more complicated in their composition than vegetables.

Charles. Are they also resolvable into a few general principles?

Tutor. They are: the names of the principal of which are as follow: animal jelly, or gelatine; albumen; gluten, or fibrin; animal resins; animal sugar, and animal oils. The animal acids have already been noticed.

James. The names correspond very much to those of the vegetable substances.

Tutor. The constituent principles also are nearly the same in both; but animal substances contain more nitrogen, or azote, and phosphorus; and the vegetable substances more carbon and hydrogen.

Charles. In what part of animals is the gelatine found?

Tutor. It is dispersed in every part, even in the bones; but it exists in the greatest quantity in the tendons, membranes, and the skin.

James. What are the properties of this substance?

Tutor. The distinguishing characteristics are, 1. A solution of it in warm water concretes, on cooling, into a gelatinous mass; 2. When the solution is evaporated, it forms a tough semi-transparent mass, which may again be dissolved in water.

Charles. Is it glue to which you refer?

Tutor. I do; gelatine, when evaporated, forms the basis of glue, isinglass, and portable soup; and it constitutes the nutritious parts of jellies. It may be extracted from all the soft parts of animals, and from the bones, by means of a digester.*

James. Do not animal jellies soon become sour?

Tutor. The solution of gelatine, exposed to the air, undergoes the acetous fermentation, and soon spoils; soup, therefore, intended to be kept, is evaporated to dryness; and, in that state, like glue or isinglass, it may be preserved almost any length of time.

The union of gelatine, in the skin, with tannin, constitutes leather.

Charles. What is albumen?

Tutor. It is the principal constituent part of the serum of blood; the white of eggs, as it is called, consists almost entirely of albumen. It is insoluble in water, alcohol, or oil; and coagulates, by a heat of 160° Fahrenheit, into a white solid mass. You see the reason why sugar may be refined indiscriminately, either by the serum of blood or the whites of eggs.

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* See Scientific Dialogues, vol. iv. p. 183.

James. Yes: because *albumen* is the principal and constituent part of both.

Tutor. Dr. Henry says, that albumen not only forms a large part of the blood and solid parts of animals, but, with the exception of water, composes, perhaps, the largest part of the animal substance.

Charles. What is the animal gluten or fibrin?

Tutor. It is fibrous, and forms the basis of the muscular or fleshy parts of animals; it has a white colour, and is destitute of taste and smell.

James. How is it obtained in this pure state?

Tutor. By washing away all the other parts from the muscular fibre; or it may be had from coagulated blood, by laying it on a linen strainer, and pouring water upon it, till a white fibrous matter alone remains.

Charles. Can this substance, like gelatine, be dissolved in water?

Tutor. No, except by the heat of a digester; it is insoluble also in oils, alcohol, and ether. But in acids it is easily dissolved; and also in alkalies. By its union with the latter, soap is formed. Hence soap has been made from wool.

Animal resins are found in the bile, and are of a dark brown colour; but spread out thinly on a white ground, they exhibit a bright grass green. They are intensely bitter. They are soluble in water and alcohol.

James. Is the animal resin found only in the bile?

Tutor. There are several animal substances, which possess similar qualities; as the wax found in the ear, ambergris, castor, &c.

Charles. In what part is the animal sugar found?

Tutor. It enters largely into the composition of milk, and other animal fluids.

James. How is it obtained from milk?

Tutor. Milk, if suffered to rest, throws up cream; this being taken off, the remainder becomes sour, and separates into a curd of whey; the latter is similar to serum, mixed with sugar and lactic acid.

The whey is to be evaporated to the consistence of honey, and when cool it concretes into a solid mass, which is to be dissolved in water, clarified by whites of eggs, filtered, and again evaporated. On cooling, white crystals are deposited, which are sugar of milk.

Charles. Does it differ in its properties from vegetable sugar?

Tutor. Yes, it does: it requires, for solution, seven parts of water, and it is insoluble in alcohol.

Milk may be made to pass into the vinous *fermentation:* and, among the Tartar tribes, *a spiritous* intoxicating liquor is made from mares' milk, which is in high request in that country.

James. What is meant by animal oils?

Tutor. Among these are ranked, by chemists, butter, fat, spermaceti, &c.

Charles. Butter is obtained from cream.

Tutor. Yes; it is never found ready formed in any animal substance, but it possesses the properties of an oil, and mixes readily with other oily bodies. Butter, when distilled in a water bath, gives over water, an acid, and an oil.

Under the denomination *fat* is included suet, which is brittle; and lard, which is soft and semifluid.

James. What are the properties of this?

Tutor. Fat is insoluble in water, alcohol, and ether; the strong acids decompose it; and with the alkalies it combines and forms soap.

Spermaceti bears some resemblance to wax, but it is more readily fusible. Pure potass acts upon it, and it is decomposed by acids.

Even the muscular or lean part of animals may be converted into a substance resembling spermaceti.

Charles. How is that effected?

Tutor. The fleshy part of an animal is confined in a box, in which a number of holes are made, and which is kept for a considerable time under the surface of a running stream. In a few months the change takes place spontaneously. The French chemists call the substance thus obtained *adipocire.*

James. Is it like spermaceti in appearance ?

Tutor. It is of a light yellow colour, of the consistence of tallow ; but it differs in many respects both from tallow and spermaceti.

Charles. Of what are bones composed ?

Tutor. Besides gelatine and fat, which may be obtained from bones, they contain three earthy salts ; namely, 1. the phosphate of lime, which constitutes by far the greater part of the whole ; 2. carbonate of lime ; and, 3. sulphate of lime.

James. Are the finger and toe nails composed of the same substances as the bones ?

Tutor. No ; they and the horns and hoofs of animals are said to resemble coagulated albumen. But egg shells, and the shells of lobsters, and other crustaceous fish, nearly resemble bones in their composition ; but in these the carbonate of lime predominates. That beautiful substance, mother of pearl, is composed of carbonate of lime and membrane. The scales of fishes are composed of membrane and phosphate of lime.

CONVERSATION XXVIII.

Of Mineral Waters.

TUTOR. The last subject that I shall at present discuss with you, respects the *mineral waters.*

Charles. How are they distinguished?

Tutor. All waters, distinguished from common water by a peculiar smell, taste, and colour, and which, in consequence of these properties, cannot be applied to the purposes of domestic economy, have been called mineral waters.

James. What are the causes of these peculiar properties?

Tutor. The substances hitherto found in mineral waters are, 1. air and its component parts, oxygen and azotic gas; 2. acids; 3. alkalies and earths; 4. salts.

Charles. Does any mineral water contain all these substances?

Tutor. Few contain more than five or six of *these substances* together. Air is contained in most of them, but its proportion does not exceed the one-twenty-eighth of the bulk of water. Oxygen gas is rarely detected in water. Azotic gas is found in the Buxton and Harrowgate waters, and in those of Lemington Priors.

James. What are the acids discovered in mineral waters?

Tutor. *Carbonic acid* is found in the Pyrmont waters: *sulphuric* acid in several hot mineral waters in Italy, which are situated in the neighbourhood of volcanoes; the *boracic acid* in some of the lakes of Italy; and sulphuretted hydrogen gas is the most conspicuous ingredient in waters denominated hepatic, or sulphureous.

Charles. Are all the alkalies found in mineral waters?

Tutor. No: soda is the only one found uncombined; and the only earthy bodies are silica and lime. Soda was discovered in the hot mineral springs of Geyzer, in Iceland; in most other cases, the soda is combined with carbonic acid. In the same, and many other waters, silica has been found.

James. Is there not some particular substance that usually predominates in each mineral water?

Tutor. Yes, there is; and on that account mineral waters are usually divided into classes, distinguished by that substance.

Charles. Into how many classes are they divided?

Tutor. Into four, *viz.*, the

1. Acidulous,
2. Chalybeate,
3. Hepatic,
4. Saline.

James. How are the *acidulous* waters distinguished ?

Tutor. By their acid taste, and by their sparkling like Champagne wine when poured into the glass. They contain a considerable proportion of carbonic acid, and generally some common salt and earthy carbonates.

Charles. The *chalybeate* waters contain, I suppose, some iron ?

Tutor. They do, and are distinguished by the property which they have of turning black with the tincture of nut-galls. The iron is usually held in solution by carbonic acid ; and, if the acid is in excess, the waters are not only chalybeate but acidulous. This is the case with the waters of Spa and Pyrmont.

James. What are *hepatic* waters ?

Tutor. They are those which contain sulphuretted hydrogen gas, and which are easily distinguished by the odour which they exhale, and by the property which they have of blackening silver and lead.

Charles. What is meant by *saline* waters ?

Tutor. They contain salts in solution, without iron or carbonic acid in excess. These are divided into four different orders. 1. Waters with salts, whose base is lime, and generally either a *carbonate* or sulphate ; these are called *hard waters.* 2. Those in which common salt predominates, which are known by their taste, and usually contain some magnesia and calcareous salts. 3. Those that contain sulphate of magnesia, have a bitter taste, and are purgative. 4. Those that contain carbonate of soda, which are known by the property of tinging vegetable blues green.

James. Are there any methods of ascertaining the different substances, and their proportions, contained in particular waters?

Tutor. There are, but we cannot enter at large into the subject; it will be sufficient if I give you a little insight into it, and show you by what means the presence or the absence of different substances which occur in waters may be ascertained.

Charles. How are these substances discovered?

Tutor. By the addition of certain other substances to the water under examination. In consequence of the addition, some change is exhibited, which shows the presence or absence of bodies suspected.

James. Are the substances thus employed called tests?

Tutor. They are, as being the instruments by means of which the analysis of water is accomplished. Suppose, for instance, *carbonic acid* is suspected to be present in water to be analyzed; I must try it with lime-water; and, if there be any carbonic acid uncombined, it will occasion a *precipitate of* the lime, which is soluble, with *effervescence*, in muriatic acid. The presence of carbonic acid may be ascertained by tincture of turnsole, which discovers also the presence of any other acid.

Charles. I should not then be able to say, whether it was the carbonic acid or any other.

Tutor. But, by boiling the water, this would be easily known ; because, if it were the carbonic acid in the water, it would lose the property of reddening the vegetable blue when boiled.

James. Are vegetable colours good tests of the existence of acids and alkalies in mineral waters ?

Tutor. Yes, they are : paper, dipped in an infusion of red cabbage, will discover an acid, or an alkali, in any mineral water ; the former will change it to a red, and the latter to a green.

Charles. How would you discover the sulphuretted hydrogen gas ?

Tutor. By means of an acetite of lead : letters written on paper with this, will, if dipped into water containing this gas, be instantly changed to *black.*

James. In some mineral waters there is *sulphuric acid ;* how would that be ascertained?

Tutor. By the addition of the muriate of barytes, or the muriate of lime ; either of which will form a precipitate ; but the former is the most delicate test, it being capable of detecting the presence of sulphuric acid uncombined, when it does not exceed the millionth part of the water.

Lime, in water, may be discovered by the addition of some oxalic acid, which occasions a white precipitate.(*a*)

If water is supposed to contain *iron*, the tincture of galls is a good test, and will exhibit a purple or black colour, if there be iron in the water. If the tincture has no effect upon the water after it has been boiled, though it coloured it before, the iron is in the state of a carbonate. But if it still changes colour, the iron is suspended by a fixed acid.

Muriatic acid is detected by a nitrate of silver, which gives a white precipitate in water, containing a very minute portion of this acid: and *boracic acid* is discovered by means of the acetate of lead.

Charles. Suppose the water to contain two or more species of gas, how could they be distinguished?

Tutor. If the carbonic and azotic gases are mixed together, and agitated over water, the former will be absorbed, but not the latter. To obtain, therefore, the gases, that may be in mineral waters, heat must be employed, and the gas received over mercury. The next step is to evaporate a considerable quantity of water, and to collect the residuum, which is to be put into a phial with alcohol. They must be shaken together; and, after standing a few hours, the mixture must be filtered; the alcohol dissolves all the deliquescent salts, as the muriate of lime, &c. To the residuum, not soluble in alcohol, add distilled water, which will take up other salts ; and what remains generally consists of alumina or siliceous earths. After this, the solutions in alcohol and in water are to be examined by proper tests, which will enable us to ascertain the nature and quantity of each salt which they contain.

James. Can you confirm your analytical proof by synthesis, and thus procure a water similar to one you have examined.

Tutor. Those waters that contain only solid ingredients are easily imitated ; but such as contain gaseous substances frequently require a good deal of contrivance. In other cases, the whole may be done by means of an apparatus, contrived by Dr. Nooth.

Charles. Was it invented for this purpose ?

Tutor. It was : and it is generally denominated Nooth's apparatus for making artificial waters. A (Fig. 18) is the upper vessel, the neck of which reaches nearly to the centre of the middle one, B, which is half filled with water, and it has a glass valve, through which the extricated gas rises. At C the materials are put in. F, in the figure just above, represents the valve on a larger scale.

James. By what means would you imitate any water ; the Bristol water, for instance ?

Tutor. I examine and find, that the Bristol water, in its natural state, is indebted for its principal properties to the muriate of magnesia, muriate of soda, and sulphate of soda, besides the carbonic acid gas. I, therefore, by means of Nooth's apparatus, impregnate the water with carbonic acid, and then add to it the above-mentioned salts, in proper proportions. If the water be then heated to 74°, it will possess the same properties as the natural water when newly drawn.

Tunbridge Wells water is imitated by impregnating distilled water with carbonic acid gas as before, and then suspending in it iron wire, or iron filings. The quantity of iron dissolved will be in proportion to the quantity of acid absorbed.

The analysis of water is important, also, with regard to many of the more common concerns of life. If water contains lime, combined with any of the acids, it is unfit for brewing, distilling, tea making, &c.; it is usually denominated hard water.

Charles. Is it also unfit for washing linen?

Tutor. It is; because it will not so easily dissolve the greasy matters, but chiefly because it decomposes the soap. In this state it is also unfit for several culinary operations.

James. How is it remedied?

Tutor. Lime is, in general, held in solution by the carbonic or sulphuric acids; the lime, as I have just now shown, is detected by the oxalic acid; the sulphuric acid by means of the muriate of barytes; and the carbonic acid by lime-water.

If carbonate of lime render the water hard, it may be purified by boiling, which drives off the carbonic acid gas, and precipitates the lime ; but when it is caused by the sulphate of lime, a solution of potass may be poured into a given quantity of water, as long as it occasions any turbidness. In this way it is easy to determine the quantity of alkali which a given quantity of water requires for its correction ; and, when this is done, it is easy to put a proper quantity of the salt into the water ; let it remain a few hours, decant the liquid from the sediment, and it will be fit for any domestic purposes.

Putrid water is purified by means of charcoal ; and water, put into casks that have been newly charred, will keep sweet a very long time.

APPENDIX.

Of the Gas Lights.

We have, in the first volume (page 159,) referred to the subject of Gas Lights, meaning to give, in this place, a more enlarged account of the subject; but we have already extended the volumes so much, that we must necessarily be brief in our observations.

To obtain carburetted hydrogen, or coal gas, from common pit coal, and to apply it to the purposes of illumination, the coal is introduced into large iron cylinders, called retorts, to the apertures of which iron pipes are adapted, terminating in a vessel or vessels intended to collect and purify the gas. The retorts, being filled with coal, and made air tight, are placed upon the fire, or rather surrounded by fire, the action of which extricates the gaseous products from the coals, together with a watery ammoniacal vapour, and a tenacious bituminous fluid, or tar.

The liquid substances are conveyed into proper vessels, and the gaseous products are conducted by means of pipes, into a reservoir. From this there are other pipes, that branch out into smaller ramifications, until they terminate at the places where the lights are wanted. The extremities of the pipes have small apertures, out of which the gas issues; and the streams of gas, being lighted at those apertures, burn with a clear and steady flame, as long as the supply of gas continues.

The pipes, which come from the gasometer, are furnished with stop cocks, to regulate the admission of the gas. The burners are formed in various ways; as in the shape of a tube ending with a simple orifice, from which the gas issues in a stream; or two concentric tubes of brass are placed at a very small distance from each other, and closed at the bottom. The gas, which enters between these cylinders, when lighted forms an Argand lamp, which is supplied by an internal and external current of air, in the usual manner. Another method is by two concentric tubes, closed at the top with a ring, having small perforations, out of which the gas alone can issue; thus forming minute but distinct streams of light. This is chiefly Mr. Accum's account, who has given, in his work (page 95,) a description of a *gas apparatus*, which, he says, will be found *very convenient* for exhibiting, in the small way, the general nature of this new art of illumination; while it may serve to ascertain, at a trifling expense, the comparative value of different kinds of coals intended to be employed for the production of this species of light.

It consists of three distinct articles of apparatus. 1. A portable furnace, by means of which the gas is prepared. 2. A purifier, or condenser, which separates and frees the products obtained from coal from all extraneous matter, and renders the gas fit for the purposes of illuminations. 3. A gasometer, or reservoir, for receiving and preserving the purified stock of gas, from which it may be transferred and distributed as occasion requires.

On the large scale, the gasometer consists of two principal parts, namely, an interior vessel, designed to contain the gas, and an outer vessel, in which the former is suspended. The latter contains the water, by which the gas is confined. The interior vessel, which contains the gas, is suspended by chains, hung over wheels, or pulleys, to which weights are attached, so to balance the weight of the gasometer as to allow its slow descent in such a manner as properly to supply the lamps with the requisite quantity of gas.

Hence the use of the gasometer is partly to equalize the evolution of the gas, which comes from the retort more quickly at some times than at others. When this happens, the vessel rises *up to receive* it; and, when the stream from *the retort* diminishes, the weight of the gasometer expels its contents, provided the main cock be open.

We shall close this account with Mr. Murdock's calculations, as to the saving that has been made in the manufactory of Messrs. Phillips and Lee at Manchester, where the gas lights have been in constant use some years.—The whole of the rooms of this cotton mill, which is one of the largest in the kingdom, as well as its counting-houses and store-rooms, and the adjacent dwelling house, are lighted with the gas obtained from coal. The quantity of light used during the hours of burning, has been ascertained to be about equal to the light of 2500 mould candles, of six to the pound, each of the candles consuming at the rate of $\frac{4}{10}$ths of an ounce of tallow per hour. The coal, says Mr. Murdock, is distilled in large iron retorts, which, during the winter season, are kept constantly at work, except during the intervals of charging; and the gas, as it rises from them, is conveyed, by iron pipes, into large reservoirs, or gasometers, where it is washed and purified, previously to its being conveyed through other pipes, called mains, to the mill. These mains branch off in a variety of ramifications, forming a total length of several miles, and diminish in size, as the quantity of gas required to be passed through them becomes less. The burners, in which the gas is consumed, are connected with the *above mains* by short tubes, each of which is *furnished* with a cock, to regulate the admission of the gas to each burner, and to cut it totally off, when requisite. This latter operation may likewise be instantaneously performed throughout the whole of the burners in each room, by turning a cock, with which each main is provided near its entrance into the room.

There are two kinds of burners; the one on the principle of the Argand lamp: the other is a small curved tube, with a conical end, having three circular apertures, or perforations, of about the $\frac{1}{30}$th of an inch in diameter, so placed that the gas issues in jets, in the form of a fleur-de-lis. The number of burners employed in all the buildings amounts to 271 Argands, and 683 of the others, each of the former giving a light equal to that of four candles, and each of the latter a light equal to two and a quarter of the same candles.

When thus regulated, the whole of the above burners require an hourly supply of 1250 cubic feet of the gas produced from cannel coal. The time, during which the gas light is used, may be reckoned, on the average of the whole year, at least, at two hours per day of twenty-four hours, and for this the consumption will be 1250 + 2 = 2500 cubic feet of gas per day: to produce this quantity, seven hundred weight of cannel coal is required in the retort: this is bought at 1s. 3½d. per hundred weight, or 8s. for the seven hundred weight. Multiplying by the number of working days in the year, or 313, the annual consumption will be 110 tons, the cost of which is 125*l.* To this must be added forty tons of good common coal, at 10s. per ton, required to heat the retorts.

The 110 tons of cannel coal, when distilled, produce about seventy tons of coke, worth 93*l.* The quantity of tar produced from each ton of cannel coal is from eleven to twelve ale gallons. In pursuing the calculation, Mr. Murdock makes the saving of gas lights in comparison with those yielded by means of candles, to be about 1400*l.* per annum. This is upon the supposition that the lights are to burn only two hours per day; but the advantage is still greater, if the lights should be required for three hours or more in the twenty-four.

Mr. Accum, in his examination in the house of lords on the subject, says, "from reiterated experiments I am enabled to say, that a hundred weight of Newcastle coals produces from 250 to 300 cubic feet of gas; and, with regard to the light that is obtained from the combustion of this quantity of gas, I am enabled to state, that nineteen feet of the gas is equal to a pound of tallow candles, six to the pound." Mr. Accum goes on, and says, "a hundred weight of coals produces from four to five pounds of tar, which is worth from 33s. to 36s. per barrel. A chaldron of coals produces sixty pounds of pitch, which is worth 1½d. per pound; and a chaldron of coals has produced me thirty-two pounds of *essential oil*, worth about four guineas. With *regard to* the quantity of asphaltum, from one chaldron of coals I obtained from twenty-eight to thirty-two pounds, which I could sell at 9*l.* per hundred weight." Besides this, Mr. Accum states, that his chaldron of coals produced a quantity of ammoniacal liquor, which he manufactured into carbonate, or muriate of ammonia, the value of which was very considerable.

Questions, and other Exercises, on the several Conversations in the foregoing Volume.

CONVERSATION I.

What are the characteristics of the acid supporters?

How many are there of these?

From what is the nitric acid formed, and what are its component parts?

Can the acid be readily analyzed?

What are its properties?

Has it an affinity for water?

What is aquafortis?

To what is it applied?

How is it obtained on a large scale?

How is it decomposed?

Whence does the inflammation proceed in a mixture of the nitric acid and oil of turpentine?

What effect has it on the metals?

What is the cause of the heat and red fumes?

How is it known that an acid is formed?

Why does a mixture of nitric acid and snow produce cold?

With what substances does it combine, and what are its compounds called?

Of what is nitrous **acid formed?**

CONVERSATION II.

Where is the muriatic acid found, and how is it obtained?

In what state is it the purest?

How is it obtained in this state?

Explain the use of the vessel represented by Fig. 8.

What are the properties of the muriatic acid gas?

With what substances does it unite?

Explain the reason of the experiment made with this acid and nitrate of silver.

What is it called when combined with oxygen?

What are the properties of the acid in this state, and with what substances does it unite?

For what purpose is the oxymuriatic acid used?

What is aqua-regia, and what is it now called?

How is the nitro-muriatic acid obtained?

Explain the structure and uses of Woulfe's apparatus.

CONVERSATION III.

What is the term *chlorine* meant to denote?

Whence is the word derived?

What arguments go to prove that chlorine is an elementary substance?

What is the most decisive fact in support of this?

How is muriatic acid formed?

In what common substance is chlorine found?

What theory is adopted to account for the destruction of colours by chlorine?

What are the chief properties of chlorine?

What are the salts of chlorine?

What are the distinguishing properties of the hyperoxymuriate of potass?

Can you give an account of the experiments by Dr. Henry?

What is meant by euchlorine, and whence is the name derived?

In what way are chlorine and oxygen made to combine?

What detonating compound is formed of chlorine and nitrogen, and how is it obtained?

What action have chlorine and hydrogen upon one another?

What effect is produced by burning potassium in chlorine?

How does Sir Humphrey Davy prove that chlorine is a simple body?

How is phosgene gas obtained?

How is the decomposition of water effected by the oxy muriate of sulphur?

Can you give an account of the combustion of metals in chlorine?

CONVERSATION IV.

What were the combustible acids formerly denominated?

Of what do these acids consist?

How are they named?

Into what classes are they distinguished?

What causes the difference in these acids?

In what states is the acetous acid employed?

How is vinegar made?

Explain the mode in which fluids are distilled.

How is the acetous acid concentrated?

With what substances does this acid unite, and what are the compounds?

Does it act upon the metals?

How is the acetic ether made?

From what is the benzoic acid formed?

What are the combinations of this acid?

How is this acid obtained, and under what name is it known?

In what is it soluble?

From what is the succinic acid obtained, and what are its properties?

What are the compounds of this acid called?

How is the camphoric acid obtained?

From what is the oxalic acid obtained, and by what *means?*

With what substances does it combine?
Does it act upon metals?
For what is it used?
For what is it an excellent test?

CONVERSATION V.

From what and how is the metallic acid obtained, and what compounds are made with it?

How is the tartaric acid obtained, and what are its properties?

With what does it combine, and what are the compounds called?

From what is the citric acid made?

With what substances does it combine, and of what use is it?

What is meant by sebacic acid, and in what state is it obtained?

Whence is saclactic acid obtained, and what is the origin of its name?

Of what are saccolates compounded?

From what is the laccic acid obtained?

From what is the malic acid obtained in great plenty?

What produces the lactic acid?

From what is the suberic acid obtained, and with what does it combine?

How is the gallic acid obtained?

What is the principal ingredient of ink?

What is the theory of ink-making?

Why is there no precipitate in good ink?

For what is the gallic acid used?

From what is the Prussic acid obtained?*

CONVERSATION VI.

Of what nature is the newly discovered substance iodine?

How did it obtain its name?

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* *The tutor will find questions formed to his hand in p. 37 and 38, which need not be repeated here.*

Who made the original discovery, and by whom was it pursued to a considerable degree of perfection?

Describe the method of obtaining iodine.

Mention some of the more remarkable properties belonging to this substance.

In what way can iodine be combined with oxygen?

How is hydiodic acid obtained?

When iodine and nitrogen are united, what remarkable circumstance attends the compound?

Has iodine an affinity for hydrogen?

What effect has the hydiodic gas upon the metals?

What remarkable properties attach to hydiodic acid gas?

How is this gas decomposed?

What effect has iodine on sulphur and phosphorus?

What is the iode of potassium?

Give a description of hydrates.

What effect has iodine on chlorine?

Mention the reasons that lead one to believe that iodine is a simple substance?

What are Dr. Henry's observations on the discovery of iodine?

How is iodine detected?

CONVERSATION VII.

How are the metals described?

Into what classes are the metals divided?

Why is mercury reckoned among the malleable metals?

How were the metals named by the ancients?

Why is there no metal, the name of which is to correspond with the earth?

Whence are metals had?

In what state are they dug out of the earth?

What is meant by the term matrix?

Are metals found in a state of purity?

How are they obtained from the ores?

What is the reason of the operations of washing and roasting the ores of metals?

What are the oxydes?

With what substances will metals combine?

How do the metals unite with the earths?

Explain the nature of the different oxydes, and the reason of their names.

What compounds are made from the union of some of the metals?

What is meant by an amalgam?

What are those metals called, which were formerly denominated semi-metals?

CONVERSATION VIII.

What are the chief properties of gold?

What is its specific gravity, and in what is it soluble?

How is the solution of gold accounted for?

Can the oxyde be obtained any other way?

How many oxydes of gold are there?

With what substances will gold combine?

How is a thin sheet of gold burnt?

For what is the nitro-muriate of gold used?

How is fulminating gold made?

What are the processes in the fulmination of gold?

How are ribands gilt?

Is gold used for enamelling?

How is the purity of gold expressed?

How is the ductility of gold expressed?

What other metals have been discovered in the ore of platinum?

Enumerate the properties of these four metals.

Whence is gold had?

What are the properties of platinum?

By what means is it fused?

Can two pieces of it be welded together?

In what way is platinum oxydized?

Will it combine with the other metals?

To what use has it been applied?

Where is platinum found?

CONVERSATION IX.

What are the chief properties of silver?
Is it easily converted into an oxyde?
How is silver burnt?
With what substances will it combine?
Is our silver coin made from the pure metal?
What will decompose the nitrate of silver?
To what has the nitrate of silver been applied?
Is the nitrate of silver decomposed by the other metals?
How are barometer-plates, and other things of the same sort, silvered over?
By what process is metal plated over?
What is the thickness of silver plating?
How is the arbor Dianæ formed?
Where is silver found?
How is it obtained from the ore?

CONVERSATION X.

What are the properties of mercury?
Can it be rendered malleable and volatile?
Does it readily combine with oxygen?
Is it combustible?
In what acids is it soluble?
How many oxydes of mercury are there?
With what substances will it combine?
What is that formerly called ethiops mineral?
What is the composition of vermillion?
What other names are applied to it?
How is mercury obtained from cinnabar?
How is the phosphoret of mercury formed?
How is the amalgam of gold formed?
Is mercury, if attached to gold coin, easily evaporated?
Explain the theory of gilding metals.
What is the fulminating powder of mercury made wi
What two solid substances rubbed together bec fluid?

What is that substance which used to be called turbith mineral?

Where does mercury come from?

To what uses is it applied?

How is mercury distilled, and what is the object of the process?

CONVERSATION XI.

What are the chief properties of copper?

What is verdigris?

Is copper easily reduced to the state of an oxyde?

What renders copper vessels dangerous in the processes of cookery?

Can they be used without risk?

How many oxydes of copper are there?

Can copper be burnt?

With what substance does copper combine?

How much copper is there in our gold coin?

What proportion of copper is there in the silver coin?

For what are the sulphates used?

What are the properties of copper combined with phosphorus?

How is the nitrate of copper prepared?

Where does copper chiefly come from?

How is it separated from other metals?

CONVERSATION XII.

What are the principal properties of iron?

What are the oxydes of iron?

What is common rust of iron?

With what substances will it combine?

How are artificial earthquakes produced?

For what is the carburet of iron used?

Of what is cast iron composed?

How is iron obtained from the ore?

By what means is cast iron converted into wrought iron?

What is steel, and what are its properties?

How may steel be known from cast iron?

With what substances will iron combine?

Are the salts made from iron useful in the manufactures?

With what substances does the sulphate of iron afford a sympathetic ink?

What will remove ink-stains?

Why do ink-stains degenerate into iron moulds?

How does this happen almost immediately after the first washing?

CONVERSATION XIII.

Of what are saucepans made, that are usually called tin-ware?

What are the properties of tin?

Is tin easily fused?

Is tin easily oxydated?

Of what use is the oxyde of tin?

With what substances will tin unite?

To what purpose is tin-foil applied?

How are plain mirrors silvered?

To what purpose are the alloys of tin applied?

Why and how are copper vessels lined with tin?

By what means are the plates made, of which tin vessels are manufactured?

How are pins tinned over?

Can tin be burnt?

Is it soluble in the acids?

To what useful purposes is tin applied?

Where is it chiefly found?

What are the chief properties of lead?

How many oxydes of lead are there?

In what manner do they combine with other metals?

How is lead used in separating gold and silver from the baser metals?

What is litharge?

With what metals will lead combine?

To what are the combinations applied?

How is the muriate of soda decomposed by the oxyde of lead?

For what are the salts of lead used?

How is the silver tree made, and what is the theory of it?

Where is lead found?

To what purpose has the acetate of lead been applied?

CONVERSATION XIV.

What are the chief properties of nickel?

Does it readily combine with oxygen?

With what other substances does it unite?

For what purposes is nickel employed?

What are the chief properties of zinc?

What effect has the air and water upon it?

How is the oxyde of zinc formed?

How many oxydes are there?

What is blende?

What are the alloys of zinc?

How is zinc obtained?

Are there any salts of zinc?

What is that substance which is commonly called white vitriol?

To what is zinc applied?

Is it used in artificial fireworks?

What are the chief properties of bismuth?

Under what circumstances does bismuth take fire?

What are the oxydes of bismuth, and to what uses are they applied?

With what substances does it combine?

What is bismuth used for?

CONVERSATION XV.

What are the principal properties of antimony?

What is that which is sold in the shops as antimony?

How is it obtained in a metallic form?

What is meant by the term regulus?

How many oxydes of antimony are there?

How is the glass of antimony obtained?

What is that substance which is usually called kermes mineral?

With what substances does antimony combine?

What is the alloy of tin and antimony used for?

Are the salts of antimony in much use?

Where is antimony found?

Explain the structure of a reverberatory furnace.

What are the properties of tellurium?

Explain the structure of the self-acting blow-pipe.

Where is the tellurium found?

What is that substance, which in the shops is called arsenic?

What are the properties of arsenic?

Is it readily oxydated?

How many oxydes are there of arsenic, and in what do they resemble acids?

What is the old name of the sulphuret of arsenic, where is it found, and for what is it used?

Can arsenic be burnt?

Under what circumstances does it burn with great rapidity?

Do you recollect the experiment to prove this?

What effect has arsenic upon iron?

To what purposes is it employed?

What is the best antidote to arsenic if taken into the human body?

Where is this metal found, and in what state?

CONVERSATION XVI.

What is cobalt, and what are its properties?

Where is it found, and by whom is it prepared?

How is it oxydated?

How many oxydes are there?

Explain the difference between cobalt, zaffre, and smalt.

Is cobalt soluble in any of the acids?

In what way is a sympathetic ink made from cobalt, and how is it to be used?

Is cobalt found in any parts of our own country?

In what state is manganese found?

What are its most remarkable properties?

How many oxydes of manganese are there?

What are the component parts of the black oxyde of manganese?

Explain the structure of a wind furnace?

In what state is manganese generally found?

Why has manganese been called the *chameleon mineral?*

Where is this substance found?

To what purposes is it applied?

What is tungsten?

What are its chief properties?

How many oxydes are there?

What are the properties of the tungstic acid?

CONVERSATION XVII.

How is molybdenum described, and from what mineral is it obtained?

How is the metal oxydated?

What are the chief properties of molybdic acid?

With what substances will this acid combine?

How many oxydes are there of molybdenum?

Which of the mineral acids act upon this metal?

Whence does uranium derive its name, and how is it described?

How is it converted into an oxyde?

What are the properties of titanium?

What is chromium, or chrome, and what are its properties?

What are the principal combinations with the chromic acid?

How is columbium described, and with what substances does it combine?

Whence is the tantalite obtained, and how is it described?

CONVERSATION XVIII.

What substances are comprehended under the name of *lts?*

Where is nitre, or the nitrate of potass found?

How is it formed artificially?

What are the salts of soda?

Where is the carbonate of soda formed?

Is the sulphate of soda found in a state of nature?

Is not the muriate of soda found very generally?

Where is the borate of soda found?

What do chemists generally comprise under the general name of salts?

How is the number of salts regulated?

What is meant by *neutral salts*?

How are the prepositions *sub* and *super* applied?

Explain this by an example.

What is the distinction between the salts, whose names end in *ate*, and of those whose names end in *ite*?

How are the genera of salts denominated, and the species distinguished?

How are the triple salts distinguished?

Into what other classes are salts divided?

Are the common names, or those introduced of late years into Chemistry, the most forcible and intelligible?

Give me an instance or two in support of your opinion.

Why do some of the common names mislead?

CONVERSATION XIX.

By what properties are the muriates distinguished?

How many muriates are there?

Why is the muriate of magnesia and ammonia a triple salt?

Which are the most important of the muriates?

How is salt, or the muriate of soda obtained?

How is the muriatic acid obtained?

How is soda got?

To what purpose is salt applied?

Whence did the muriate of ammonia (sal-ammoniac) derive its name?

How and in what state is it obtained?

What property is there belonging to this salt?

To what use is it applied?

What are the hyperoxygenized muriates, and what are the properties belonging to them ?

Can you recollect any experiments made with them ?

CONVERSATION XX.

How are sulphates distinguished ?

How are Epsom salts obtained ?

What is extracted from these salts ?

What number of sulphates is there, and how are they arranged ?

In what does the difference consist between the sulphate and the super-sulphate of potass ?

Can the super-sulphate be reduced to a sulphate, and how ?

What other names belong to the sulphate of lime ?

In what class of bodies is alum ranked ?

For what is it used ?

Of what does pyrophorus consist ?

What are the properties belonging to the phosphates ?

Which is the most important of these salts, and how is it obtained ?

Where is this salt found in a natural state, and what is it called ?

Is it found in other substances ?

For what is the phosphate of soda employed, and why ?

CONVERSATION XXI.

What are the properties of the carbonates ?

How are these salts obtained, and how many are there ?

Which is the most important of the carbonates, and what are its other names ?

What are the properties of the nitrates ?

How many of these salts are there ?

What is nitre, or salt-petre, named in the new Chemistry ?

Do you recollect any experiments on the nitrate of potass ?

Of what, and in what proportions is gunpowder made ?

How is it manufactured ?

In what manner is it glazed ?

What is the composition of the fulminating powder, with nitre as the principal ingredient ?

How is nitric acid obtained ?

What is the black, and what the white flux, and what are their uses ?

How many bases are there from which the metallic salts are formed ?

Are the salts made from the metals themselves ?

Is there ever more than one salt from the same metallic substance ?

When have oxydes a tendency to absorb more oxygen ?

Can you refer to an instance in point ?

CONVERSATION XXII.

How are the metallic salts distinguished ?

How are the mercurial salts characterized ?

What are the mercurial oxydes ?

How are the different mercurial salts denominated ?

What are the two species particularly noticed ?

In what case does the nitric acid act upon mercury ?

What are the distinguishing properties of the nitrate of mercury ?

What are the muriates of mercury ?

What is the difference between corrosive sublimate and calomel, and what are they denominated in the new Chemistry.

CONVERSATION XXIII.

What is the general structure of vegetables ?

To what do these several parts answer in the animal economy ?

What is a very important difference between vegetables ?

On what does the vigour of the plant depend ?

Why do multitudes of the vegetable tribe never arrive at perfection ?

Describe the first stages of animal and vegetable life ?

Of what parts do the seeds of vegetables consist ?

What is the radicle?
What are the cotyledons?
What is the plumula?
What are the constituent principles of vegetables?
What is the food of vegetables?
What are the principal substances which are met with in vegetables?
By what methods are vegetables analyzed?
How is gum obtained?
In what is gum soluble?
Of what is it composed?
Where does gum come from chiefly?

CONVERSATION XXIV.

What is meant by farina?
How is it obtained?
By what process is barley made into malt?
What are the constituent principles of farina?
From what is jelly obtained, and with what does it combine?
From what is sugar obtained?
What are its component parts?
How is it obtained from the cane?
How is it refined?
In what is gluten found?
What are its properties?
Whence is oil obtained?
What are its properties?
Describe the uses of the vessel represented in Fig. 14.
Show me the uses of the hydrostatic funnel?
In what do the fixed oils differ from the essential oils?
How is the vessel used, which is represented by Fig. 17?
In what does camphor resemble the oils?
Whence is camphor obtained?
Whence is the origin of wax, and what are its properties?
How are resins obtained, and of what are they composed?
From what is extract obtained, and what are its properties?

What are its constituent parts?
From what is caoutchouc obtained?
What are its chemical properties?
Of what principles is it composed?

CONVERSATION XXV.

From what is tannin obtained?
To what is its chief property applied?
What is the colouring principle of vegetables?
On what is the art of dying founded?
To what number may the variety of colours be reduced?
How are colours fixed in substances?
What is the process adopted in dying?
Describe what is meant by the word mordant?
For what are mordants used?
What is meant by bleaching?
From what is cork obtained?
What are the properties of the cork?
How is the fibre of wood obtained pure?
From what countries does cork come, and how is it obtained?

CONVERSATION XXVI.

How many kinds of fermentation are there?
What is fermentation?
How does it differ from putrefaction?
What things are necessary in fermentation?
What is meant by ferments?
What is leaven?
Why does the dough for bread swell?
What are the species of vinous fermentation?
To what is the strength of fermented liquors to be imputed?
What circumstances are necessary to the process of vinous fermentation?
How is the process of fermentation explained?
Of what is alcohol composed?

What are the constituent parts of wine?

How is the process of brewing conducted?

How is vinegar obtained?

What is it that changes wine or beer into vinegar?

What is meant by putrefaction, and what is formed during the change?

What circumstances are necessary to putrefaction?

What property renders alcohol very valuable?

What is ether, and how is it obtained?

By what properties is ether characterized?

CONVERSATION XXVII.

What are the constituent parts of animal substances?

How is the gelatine situated?

What are the distinguishing characteristics of gelatine?

By what process is leather made?

What are the properties of albumen?

Why is sugar refined either by the serum of blood, or the whites of eggs?

Does albumen make a large part of animal substances?

How is animal gluten obtained, and what are the properties which distinguish it?

How is soap made from it?

What properties distinguish animal resins?

From what are they obtained?

How, and from what is animal sugar obtained?

Of what do the Tartar tribes make an intoxicating liquor?

What are the animal oils?

Of what is butter composed?

By what properties is fat distinguished?

How is the lean part of animals formed into a substance resembling spermaceti?

What are the constituent parts of bones?

Of what are the nails and the horns of animals composed?

What are the constituent parts of mother-of-pearl?

Of what are the scales of fishes composed?

CONVERSATION XXVIII.

What do you mean by mineral waters?

What are the substances found in them?

By what are the Buxton and Harrowgate waters distinguished?

In what mineral waters is the *carbonic acid gas*, and in what is the sulphuric acid predominant?

How are the mineral waters classed?

By what are the acidulous waters distinguished?

What is the characteristic of chalybeate waters?

How are the hepatic waters distinguished?

How are the saline waters characterized?

How is carbonic acid discovered in water?

How is the sulphuretted hydrogen gas detected?

By what method is the sulphuric acid discovered?

How is *lime* detected?

What is the best test, if iron is suspected to exist in water?

Explain the nature of the vessel represented by Fig. 18.

How is the Bristol water imitated?

How is the Tunbridge Wells water imitated?

What is it that constitutes hard water?

For what is hard water unfit?

How can hard water be rendered fit for domestic purposes?

Is there any method of purifying putrid water?

APPENDIX.

Describe the method of obtaining carburetted hydrogen or coal gas.

How is it preserved and distributed?

How is the admission of the gas regulated?

Of what parts does the gas apparatus consist?

What is the construction of the gasometer on the large scale?

What is the use of the gasometer?

Can you give some account of Mr. Murdock's calculation?

What kind of burners are used in the manufactory at Manchester?

How many cubic feet of gas are required for the hourly supply?

What is the saving estimated at?

What is Mr. Accum's account of the matter?

NOTES,

BY AN

AMERICAN PROFESSOR OF CHEMISTRY.

Page 3 (*a*) Nitric acid is not so heavy as sulphuric, nor will it produce near so great an elevation of temperature, on being mixed with water.

Page 10. (*a*) Its action on charcoal is extremely feeble. This fact first led Sir H. Davy to question the correctness of the prevailing theory, of the action of this gas on combustibles, and eventually to the conclusion, that it contains no oxygen. V. p. 14.

Page 18. (*a*) A better way is to dip a rod into sul. acid, and let a single drop fall on the mixture.

Page 61. (*a*) Gold is found in North Carolina in the state of lumps. A mass was found there some years ago, which weighed *28lb.*

Page 61. (*a*) It would be very difficult to operate on platina in any considerable quantity by this means. It is obtained from its ores by solution in acids, and subsequent precipitation and compression.

Page 69. (*a*) It is scarcely to be doubted that this phenomenon is the effect of galvanic action.

Page 81. (*a*) Copper kettles and stew pans are frequently lined with tin, a thin coat of which adheres to the surface of the copper, and will not be separated, exce at a heat nearly twice that of boiling water. V. p. 95.

Page 101. (*a*) This effect must also be referred to galvanism.

Page 115. (*a*) This experiment should be performed with caution, on account of the poisonous fumes exhaled from the oxydized arsenic.

Page 128. (*a*) Chrome, in the state of an acid, is found combined with iron, (forming the native chromate of iron) in considerable quantity, in the neighbourhood of Baltimore. From this the beautiful pigment called chromic yellow is prepared.

Page 130. (*a*) In a chemical sense, the combinations of acids with the earths and metals, are also to be regarded as salts.

Page 142. (*a*) The hyper-oxymuriate of potash is here alluded to.

Page 143. (*a*) This is not quite correct. The hyper-oxymuriates are not fulminating powders, nor are any of their mixtures to be compared, in this respect, with several of the metallic fulminating powders.

Page 149. (*a*) There is no occasion of heating a crucible. If the mixture be put in a pan or on a shovel, and fired with an ignited coal, it succeeds very well.

Page 204. (*a*) Oxalate of ammonia is generally preferable.

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rm fluids. Fluid substances combined with an addi-
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ic. The term formerly given to the still used by
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is. The resolution of a substance into its constitu-
parts, for the purpose of examination.
——, definition of, i, 11. Complete, described, ib.
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ling. The art of rendering substances tough, which
naturally hard and brittle. Glass and iron are an-
ed by gradual cooling ; brass and copper by heat-
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Areometer. A graduated glass instrument with a bulb, which the specific gravity of liquids is ascertained.
Aroma. A term used for the odour which arises from tain vegetables, or their infusions.
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Base. A chemical term, usually applied to denote earth, the alkali, or the metal, which is combined an acid to form a salt.
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Combination. A term expressive of a true chemical union of two or more substances, in opposition to mere mechanical mixture.
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Concentration. The act of increasing the specific
of bodies. The term is usually applied to fluids
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Condensation. The act of bringing the componer
of vapour, or gas, nearer together by pressure
cold. Thus atmospheric air may be condensed b
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till it is converted into water.

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Crucibles. Vessels of indispensable use in Chemis
the various operations of fusion by heat. Th
made of baked earth, or metal, in the form of an
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Cupel, a small vessel used for refining gold and si
See Vol. ii, Plate iii, Fig. 19.

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Dephlogisticated. A term which was given by Dr P
to oxygen gas. When he first discovered this
called it dephlogisticated air.

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Digestion. The effect produced by the continued soa
a solid substance in a liquid, with the application

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Ductility. A quality of certain bodies, in consequ
which they may be drawn out to a certain lengt
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Elastic Fluids. A name sometimes given to vapours and gases. Vapour is called a fluid; gas, a permanently elastic fluid.

——— *gum.*—See *Caoutchouc.*

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Eolipile. A copper vessel with a small orifice, and partly filled with water. It is made hot, in order that the vapour of the water may rush out with violence, and carry a stream of air with it to increase the intensity of fires. It is an instrument of great antiquity.

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Hygrometers. Instruments for ascertaining th
moisture in atmospheric air.

Hyperoxygenized. A term applied to substance
combined with the largest possible quantity
We have muriatic acid, oxygenized muriatic a
peroxygenized muriatic acid. The latter can
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Muffle. A semi-cylindrical utensil, resembling the til a boat, made of baked clay; its use is that of a co to cupels in the assay furnace, to prevent the charc from falling upon the metal, or whatever is the subj of experiment.—See Plate iv, Fig. 25, vol. i.
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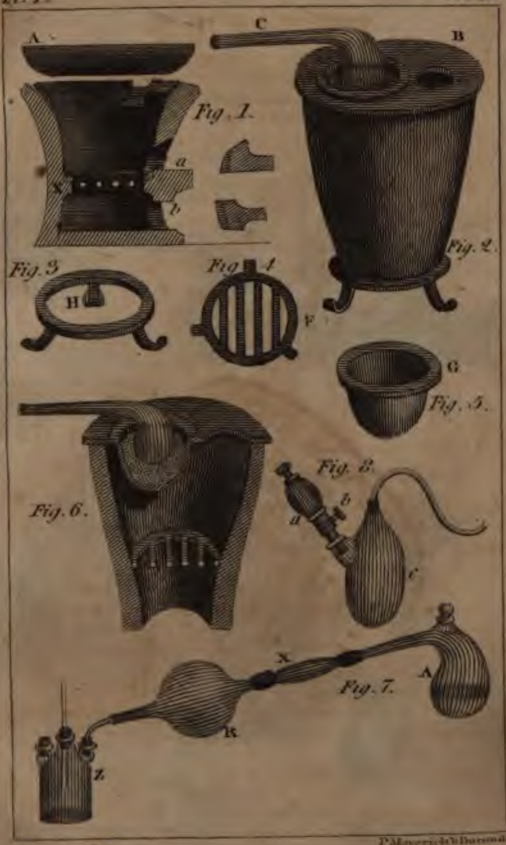

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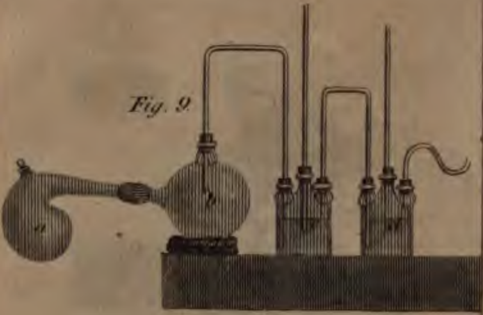
Fig. 9.



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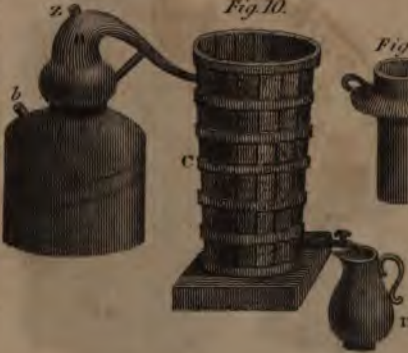

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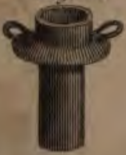

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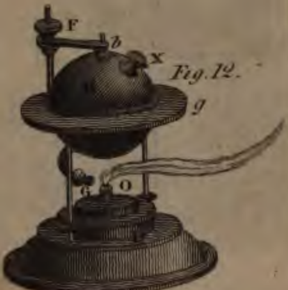
Fig. 19.

Fig. 12.



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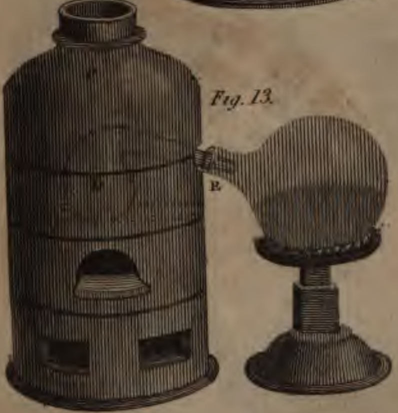

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Fig. 14.

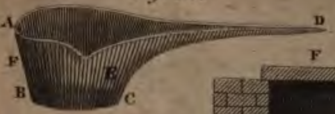
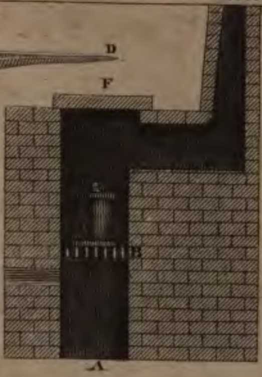


Fig. 15.



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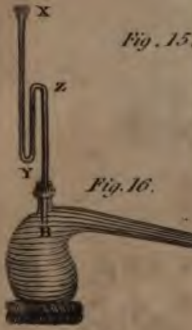

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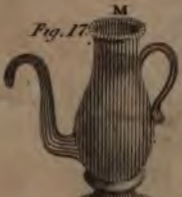

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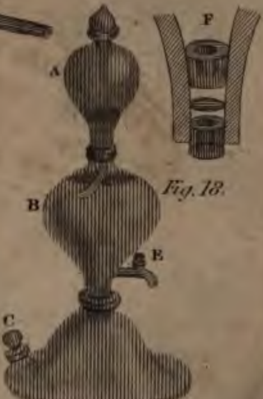

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